

PALEONTOGRAPHICAL SOCIETY.

VOL. LXIII.

THE PLEISTOCENE CANIDÆ.

PAGES 1—28; PLATES I—VI.

GANOID FISHES OF
BRITISH CARBONIFEROUS FORMATIONS.

PART I.

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FOSSIL FISHES OF THE ENGLISH CHALK.

PART V.

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THE CRETACEOUS LAMELLIBRANCHIA.

VOL. II, PART VI.

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THE MOLLUSCA OF THE CHALK.
CEPHALOPODA.

TITLE-PAGE AND INDEX.

THE BELEMNITIDÆ.

TITLE-PAGE AND INDEX.

ISSUED FOR 1909.

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PALÆONTOGRAPHICAL SOCIETY.

VOLUME LXIII.

CONTAINING

1. THE PLEISTOCENE CANIDÆ. By Prof. S. H. REYNOLDS. Six Plates.
2. THE CARBONIFEROUS GANOID FISHES. Part I, No. 4. By Dr. R. H. TRAQUAIR. Seven Plates.
3. THE FISHES OF THE ENGLISH CHALK. Part V. By Dr. A. S. WOODWARD. Six Plates.
4. THE CRETACEOUS LAMELLIBRANCHIA. Vol. II, Part VI. By Mr. H. WOODS. Ten Plates.
5. THE MOLLUSCA OF THE CHALK.—CEPHALOPODA. Part IV. By Mr. D. SHARPE. Title-page and Index.
6. BRITISH BELEMNITIDÆ.—JURASSIC. Part VI. By Prof. J. PHILLIPS. Title-page and Index.

ISSUED FOR 1909.

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PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

AGENTS FOR THE SOCIETY:
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DECEMBER, 1909.

THE PALÆONTOGRAPHICAL SOCIETY was established in the year 1847, for the purpose of figuring and describing British Fossils.

Each person subscribing ONE GUINEA is considered a Member of the Society, and is entitled to the Volume issued for the Year to which the Subscription relates. The price of the Volume to Non-subscribers is TWENTY-FIVE SHILLINGS NET.

Subscriptions are considered to be due on the 1st of January in each year.

The Annual Volumes are now issued in *two forms of Binding*: 1st, with all the Monographs stitched together and enclosed in one cover; 2nd, with each of the Monographs in a paper cover, and the whole of the separate parts enclosed in an envelope. Members wishing to obtain the Volume arranged in the LATTER FORM are requested to communicate with the Secretary.

Most of the *back volumes* are in stock. Monographs or parts of Monographs already published can be obtained, apart from the annual volumes, from Messrs. DULAU AND CO., LTD., 37, Soho Square, London, W., who will forward a complete price list on application.

Members desirous of forwarding the objects of the Society can be provided with plates and circulars for distribution on application to the Secretary, Dr. A. SMITH WOODWARD, British Museum (Nat. Hist.), South Kensington, London, S.W.

The following Monographs are in course of publication :

The Fossil Sponges, by Dr. G. J. Hinde.

The Graptolites, by Prof. Lapworth, Miss Elles, and Miss Wood.

The Cambrian Trilobites, by Mr. Philip Lake.

The Cretaceous Lamellibranchia, by Mr. H. Woods.

The Palæoniscid Fishes of the Carboniferous Formation, and the Fishes of the Old Red Sandstone, by Dr. R. H. Traquair.

The Fishes of the English Chalk, by Dr. A. Smith Woodward.

Geology
QE 701
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ANNUAL REPORT

OF THE

PALÆONTOGRAPHICAL SOCIETY, 1909,

WITH

L I S T

OF

The Council, Secretaries, and Members

AND

A LIST OF THE CONTENTS OF THE VOLUMES ALREADY
PUBLISHED.

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ANNUAL REPORT OF THE COUNCIL

FOR THE YEAR ENDING 31ST DECEMBER, 1908.

READ AND ADOPTED AT THE

ANNUAL GENERAL MEETING,

HELD AT THE APARTMENTS OF THE GEOLOGICAL SOCIETY, BURLINGTON HOUSE,
19TH MARCH, 1909.

DR. HENRY WOODWARD, F.R.S., PRESIDENT,

IN THE CHAIR.

THE Council, in presenting their Sixty-second Annual Report, are glad to be able to record satisfactory progress in the Society's work. The volume for 1908, which was issued in December, contains the final part of another Monograph, that of "Cretaceous Asteroidea," besides a small separate work, "Illustrations of Type Specimens of Inferior Oolite Ammonites," which may be regarded as a supplement to the volume devoted to those Ammonites already published. It also comprises instalments of the Monographs of "English Chalk Fishes," by Dr. A. S. Woodward; of "Cretaceous Lamellibranchia," by Mr. H. Woods; of "Cambrian Trilobites," by Mr. P. Lake; and of "British Graptolites," by the Misses Elles and Wood, edited by Prof. Lapworth. The Council have received numerous proposals for new Monographs, but are desirous, so far as possible, to complete those in progress before entering upon further undertakings.

Owing to the unexpected illness of a contributor who had promised his instalment, the volume for 1908 is smaller than usual; and six of the plates with which it is illustrated were drawn and paid for during previous years. The cost of publication was therefore below the estimate, and a small balance remains for use

when more expensive Monographs are in progress at some future time. The cost of production varies much with the degree and method of illustration, and the Council deem it advisable, when possible, to retain a small sum for unexpected outlays.

Since the last Annual Meeting the Society has sustained serious losses by death. The Council mourn more especially the loss of a distinguished Vice-President, Mr. W. H. Hudleston, F.R.S., whose valuable services had long been at the disposal of the Society. Mr. Hudleston's wide learning, sound judgment, and personal charm made him an ideal Councillor; while his monograph of the Gastropoda of the Inferior Oolite is a classic among the Society's publications. Prof. Albert Gaudry, of Paris, who had been a member of the Society for many years and attended the Jubilee Meeting in 1897, died last November. Among others may also be mentioned Sir Thomas Wardle, an enthusiastic amateur, who for some years was a member of Council. The Society's roll of membership, unfortunately, shows that these recent losses by death have not yet been repaired by accessions of new subscribers, and the Council make a special appeal to all who are interested in the study of fossils to help them.

The thanks of the Society are due to the Council of the Geological Society for permission both to store the stock of back volumes and to hold the Council Meetings and the Annual General Meeting in their apartments.

In conclusion, it is proposed that the retiring members of Council be Mr. Upfield Green, Mr. Lake, and Mr. Rudler; that the new members be Sir Archibald Geikie, Prof. Garwood, Mr. F. R. Cowper Reed, and Mr. C. Fox Strangways; that the new Vice-President be Sir Archibald Geikie; that the President be Dr. Henry Woodward; the Treasurer, Dr. G. J. Hinde; and the Secretary, Dr. A. Smith Woodward.

Annexed is the Balance-sheet.

THE PALÆONTOGRAPHICAL SOCIETY IN ACCOUNT WITH DR. GEORGE J. HINDE, F.R.S., TREASURER.

Cr.

From January 1st, 1908, to December 31st, 1908.

Dr.

	£	s.	d.	£	s.	d.	£	s.	d.
Balance at Bank from last Account	.	.	.	200	16	10			
Members' Subscriptions—1900–1907	46	48	6	0				109	1
" " 1908	339	355	19	0				0	16
" " 1909–1912	15	15	15	0				24	3
					420	0	0		8
Carriage paid by Members	.	.	.	.	1	16	2		
Sales of back stock to Members	.	.	.	.	25	18	10		
Sales by Messrs. Dulau & Co.	.	.	.	.	75	18	8		
Repaid Income Tax (1 year)	.	.	.	.	0	15	0		
Dividends on £500 Natal 3 per cent. Stock (less income tax)	.	.	.	.	14	5	0		
Sale of drawings	.	.	.	.	3	0	0		
Donation	.	.	.	.	1	6	3		
Interest on Deposit	.	.	.	.	2	16	11		
Letterpress printing, Vol. LXII	.	.	.	.					29
" " Vol. LXI	.	.	.	.					18
Paper	.	.	.	.					10
Drawing text-figures and making blocks	.	.	.	.					61
Drawing plates	.	.	.	.					8
Colotype and lithographic printing	.	.	.	.					95
									0
Binding Vol. LXII	.	.	.	.	
" " Vol. LXI	.	.	.	.					186
Packing and distribution, Vol. LXI	.	.	.	.					7
Secretary's honorarium	.	.	.	.					1
Postage and stationery	.	.	.	.					39
Fire Insurance	.	.	.	.					4
Petty charges	.	.	.	.					6
Cheque returned	.	.	.	.					2
Balance at Bank—Current Account	.	.	.	.					18
" " Deposit Account	.	.	.	.					10
									3
Cash in hand	.	.	.	.	
									243
									10
									3
									5
									6
									0
									£746
									13
									8

We have examined the above account, compared it with the vouchers, and find it to be correct; we have also seen the receipt for £500 Natal 3 per cent. Consolidated Stock.

F. L. KITCHIN.	ALFRED W. OKE.	} Auditors.
E. T. NEWTON.	GEORGE W. YOUNG.	

March 9th, 1909.

The following Address was presented by the Rev. Canon Bonney on behalf of the Society to the University of Cambridge in June, 1909, at the celebration of the Centenary of the birth of Charles Robert Darwin :—

TO THE CHANCELLOR, MASTERS, and SCHOLARS
of the UNIVERSITY OF CAMBRIDGE.

The President and Council of the PALÆONTOGRAPHICAL SOCIETY desire to associate themselves with the University of Cambridge in celebrating the Centenary of the birth of Charles Robert Darwin and the Jubilee of his great work, "The Origin of Species."

They remember with pride that he was a Member of their Society almost from its foundation till his death in 1882, contributed to their volume for 1851 a Memoir on the fossil Lepadidæ, and added to it in 1854 one on the fossil Balanidæ and Verrucidæ. They rejoice to think that his systematic studies of the Cirripedia, of which these Memoirs are one result, did much, in the opinion of most competent judges, to perfect his education as a zoologist, and enable him to deal successfully with a problem of singular difficulty.

For three centuries at least the University has been distinguished for sons eminent in almost every branch of mathematics, philosophy, and literature; it is now to be congratulated on having added to the number of its naturalists one who has secured a foremost place by the accuracy of his observations, the originality of his ideas, and the soundness of his reasonings.

(Signed) HENRY WOODWARD, *President.*

ARTHUR SMITH WOODWARD, *Secretary.*

London, June, 1909.

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CORRECTED TO 1ST NOVEMBER, 1909.

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Palæontographical Society, 1909.

A MONOGRAPH

OF THE

BRITISH PLEISTOCENE MAMMALIA

VOL. II, PART III.

THE CANIDÆ.

BY

SIDNEY H. REYNOLDS, M.A., F.G.S.,

PROFESSOR OF GEOLOGY IN THE UNIVERSITY OF BRISTOL.

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MONOGRAPH
ON
THE BRITISH MAMMALIA
OF THE
PLEISTOCENE PERIOD.
--
THE CANIDÆ.

Order—**CARNIVORA.**

FAMILY—CANIDÆ.

Genus—CANIS.

I. HISTORICAL INTRODUCTION.

AT the commencement of a previous memoir dealing with the Pleistocene¹ bears reference was made to the difficulty which the study of those animals presented owing to the practical impossibility of coming to a satisfactory conclusion with regard to the mutual relationship of the various species and varieties. That difficulty presents itself in perhaps an even more marked form in the case of the Canidæ.

The earliest reference to the existence of fossil Canidæ is Esper's² account (1774) of the finding of bones in the cave at Gailenreuth which he recognised as those of wolf. Rosenmüller³ (1794), in a pamphlet written in Latin and dealing principally with the fossil bears, stated that bones of dogs and foxes, as well as of wolves, had been found in caves, but considered that the bones of foxes were intro-

¹ The terms "Pleistocene" and "Prehistoric" are used in the following pages in the sense as defined by Dawkins and Sanford, 'Monograph of the British Pleistocene Mammalia,' vol. i, p. 7.

² 'Ausführliche Nachricht—Zoolithen Bayreuth.'

³ 'Quædam de Ossibus fossilibus animalis,' Leipzig, p. 27.

duced by diluvial action, and were not contemporaneous with the associated bear and hyæna bones. The earlier writers were disposed to doubt the identity of the canine bones found in caves with those of living species. Thus Goldfuss, who in 1810 had figured ¹ the skull of a wolf from Müggendorf, when describing thirteen years later ² (1823) a wolf's skull from Gailenreuth, regarded it as specifically distinct from *Canis lupus*.

Cuvier,³ too (1812 and 1825), was apparently disposed to regard the wolf remains in his possession as specifically distinct from the modern species. He made further comparisons of the skeletal characters of wolves and dogs, and agreed with Daubenton ⁴ (1758) in recognising the extreme difficulty in distinguishing between the skull of a wolf and that of a dog.

The first author to express himself decisively as to the identity of the fossil remains of the wolf with those of the living species was Schmerling ⁵ (1833) in his description of bones from the caverns of Liège. M. de Serres, Dubrueil, and Jeanjean ⁶ (1839), though not expressing themselves very definitely, attributed the canine bones found in the caves of Lunel Viel to the living species.

The question as to the specific identity of the recent and fossil species was, however, fully considered by de Blainville ⁷ (1844), who, in his 'Ostéographie,' discussed and summarised all the evidence, strongly supporting the view that no distinction could be drawn between the wolves, dogs, and foxes of the caves and those living at the present day.

Owen, too, in his 'British Fossil Mammals and Birds' ⁸ (1846), in which a full account of the fossil Canidæ was given, agreed that "the wolves which our ancestors extirpated were of the same species as those which . . . left their bones in the limestone caverns . . ."

Since then almost all zoologists who have considered the subject have agreed as to the specific identity of the fossil remains of the wolf with those of the living species, but Pomel (1854) and Bourguignat as lately as 1875 maintained the contrary view, the latter author retaining the name *Canis spelæus* of Goldfuss for the fossil wolves of the caverns.

Meanwhile the bones of wolf and fox had been described from many British caves, such as Kirkdale (Buckland,⁹ 1822), where, however, they were very scanty,

¹ 'Die Umgebungen von Müggendorf' (Erlangen).

² 'Säugethiere der Vorwelt,' p. 451.

³ 'Oss. Foss.,' tom. iv, iv, pp. 5—9 (1812), and *ibid.*, ed. 3, tom. iv, pp. 457—467 (1825).

⁴ In Buffon's 'Histoire Naturelle,' tom. vii, p. 53.

⁵ 'Recherches sur les Ossements fossiles des Cavernes de Liège,' tom. ii, pp. 22—46.

⁶ 'Recherches Oss. humatiles des Cavernes de Lunel Viel,' pp. 72—74.

⁷ 'Ostéographie—Carnassiers,' pp. 101—104.

⁸ 'British Fossil Mammals and Birds,' p. 132.

⁹ 'Phil. Trans.,' cxii, p. 182.

Paviland (Buckland,¹ 1824), Oreston (Clift and Whidbey,² 1823), Banwell (Rutter,³ 1829), Yealm Bridge, Devon (Bellamy,⁴ 1839). Buckland, in the 'Reliquiæ Diluvianæ'⁵ (1824), gives a table showing that these animals had been recognised in various other Pleistocene deposits, both in Britain and on the continent.

The question as to the specific identity of the fossil Canidæ of the caves with those living at the present time being settled, the far more difficult one concerning the mutual relationship of the wolves, jackals, and dogs occupied attention. This question had, as has been already mentioned, been considered by Cuvier and Daubenton. It was fully discussed in 1844 by de Blainville,⁶ who went beyond those anatomists in being unable to recognise any osteological distinction between dogs and wolves, and by Pictet⁷ (1853), who was the earliest author to suggest as the origin of the domestic dogs, not any known species of *Canis* living or fossil, but an unknown species assumed to have existed in Pleistocene times.

Between 1859 and 1885 appeared a long series of papers dealing with the Pleistocene and Prehistoric Canidæ of Ireland, which were described from the following localities: Dunshaughlin, co. Meath (Wilde,⁸ 1859, dog); Shandon, co. Clare (Adams,⁹ 1879, wolf and fox); Knockninny, co. Fermanagh (Haughton,¹⁰ 1876, wolf, dog, fox); Ballynamintra, co. Waterford (Adams,¹¹ 1881, wolf, dog); Knockmore, co. Fermanagh (Ball,¹² 1885, wolf). More recent are the records from Kesh, co. Sligo (Scharff, 1903, wolf, dog, fox), and Edenvale, co. Clare (Scharff, 1906, wolf, dog, fox, Arctic fox).

At Shandon and Kesh it is probable that deposits of both Pleistocene and Prehistoric date occur. At all the other Irish localities in the above list it is probable that the remains belong solely to the Prehistoric period.

Other important records of Pleistocene canine remains are those of Kent's Cavern, Torquay (MacEnery,¹³ 1859, wolf, fox), Wookey Hole near Wells (Dawkins,¹⁴ 1862 and 1863, wolf, fox), Creswell Crags, Derbyshire (Busk,¹⁵ 1875, wolf, fox, Arctic fox). The occurrence of the Arctic fox in Britain had not been previously noted. The records from Norwich (Denny,¹⁶ 1859, dog) and from

¹ 'Reliquiæ Diluvianæ,' p. 85.

² 'Phil. Trans.,' cxiii, p. 88.

³ 'Delin. Co. Somerset,' p. 156.

⁴ 'Nat. Hist. S. Devon.' Bellamy's account is reproduced by Pengelly in his paper on "The Literature of the Caverns near Yealmpton, S. Devon," 'Trans. Devon. Assoc.,' iv, 1871, p. 92.

⁵ 'Reliquiæ Diluvianæ,' facing p. 1.

⁶ 'Ostéographie—Carnassiers,' pp. 101—104.

⁷ 'Traité de Paléontologie,' tom. i, p. 202.

⁸ 'Proc. Roy. Irish Acad.,' vii, p. 193.

⁹ 'Trans. Roy. Irish Acad.,' xxvi (Sci.), p. 227.

¹⁰ 'Proc. Roy. Irish Acad.,' (2), ii (Sci.), p. 482.

¹¹ 'Trans. Roy. Dublin Soc.' (2), i, p. 205.

¹² Ibid. (2), iii, p. 335.

¹³ 'Cavern Researches.'

¹⁴ 'Quart. Journ. Geol. Soc.,' xviii, p. 124; and xix, p. 267.

¹⁵ Ibid., xxxi, pp. 684—687.

¹⁶ 'Proc. Yorks. Geol. Polyt. Soc.,' iii, p. 538.

Burrington Combe, Somerset (Dawkins,¹ 1864, wolf, fox), are of Prehistoric, not Pleistocene remains.

More recent are Newton's² account (1894) of the fauna of the Ightham fissure near Maidstone, in which the Arctic fox was again met with, and Newton and Arnold Bemrose's³ account (1905) of the Hoe Grange Cave, Derbyshire, where scanty remains of the wolf and common fox were found.

More comprehensive records are those of Falconer⁴ (1868), who showed that bones of both wolf and fox had been recognised in all eight of the Gower caves, and Dawkins⁵ (1869), who, in his well-known paper on the 'Distribution of the British Post-Glacial Mammals,' gives a long list of localities for canine bones.

Much additional information with regard to both the Pleistocene and Prehistoric Canidæ is contained in Dawkins and Sanford's introduction to their *Memoirs on the British Pleistocene Mammalia* (Palæontographical Society, 1866). Harting's 'Extinct British Animals,' published in 1880, though chiefly concerned with the wolf during the historic period, has some account of its occurrence in Britain in Pleistocene and Prehistoric times, and adds some further localities⁶ to Dawkins' list. Pennington's 'Notes on the Barrows and Bone Caves of Derbyshire' (1877), though treating the subject in a more or less popular fashion, contains some further information.

During the middle and latter part of the last century, too, the question of the mutual relationship of the Canidæ was not left unconsidered, being discussed by Rüttimeyer⁷ (1862), Jeitteles⁸ (1872 and 1877), and Bourguignat⁹ (1875), while more recently the subject has been taken up by Huxley¹⁰ (1880), Woldrich¹¹ (1881 and 1886), Lydekker¹² (1884), von Pelzeln¹³ (1886), Wilckens¹⁴ (1886), Nehring¹⁵ (1888), Boule¹⁶ (1889), Vieira¹⁷ (1894), Gaudry and Boule¹⁸ (1892), Studer¹⁹ (1902)

¹ 'Proc. Somerset. Arch. and Nat. Hist. Soc.,' xii, pp. 161—176.

² 'Quart. Journ. Geol. Soc.,' i, pp. 201—203.

³ *Ibid.*, lxi, pp. 49 and 50.

⁴ 'Pal. Mem.,' ii, p. 525.

⁵ 'Quart. Journ. Geol. Soc.,' xxv, p. 192.

⁶ *Op. cit.*, p. 118.

⁷ 'Untersuchung der Tierreste aus Pfahlbauten der Schweiz' (1862).

⁸ 'Mittheil. d. anthropol. Gesell. in Wien,' ii, p. 169 (1872), and 'Die Stammväter unserer Hunderassen' (1877).

⁹ 'Ann. des Sciences Géol.,' vi, p. 33.

¹⁰ 'Proc. Zool. Soc.,' 1880, pp. 238—288.

¹¹ 'Mittheil. der anthropol. Gesell. in Wien' (1881), xi, and 'Anz. Akad. Wien' (1886), p. 12.

¹² 'Palæont. Indica,' ser. 10, vol. ii, p. 240.

¹³ 'Zool. Jahrbuch,' i, pp. 225—240.

¹⁴ 'Biol. Centralbl.,' v, pp. 719 and 751.

¹⁵ 'Naturwissenschaft. Wochenschrift,' ii.

¹⁶ 'Comptes Rend.,' cviii, p. 201.

¹⁷ 'Ann. Sci. Nat. Porto,' i, p. 109.

¹⁸ 'Mat. pour l'Hist. des Temps quatern.,' fasc. iv, pp. 123—129.

¹⁹ 'Abh. schweiz. pal. Ges.,' xxviii, art. 1 (1902).

and Keller¹ (1903). A very brief summary of their several conclusions is given subsequently when dealing with the mutual relationship of the Pleistocene and Prehistoric Canidæ.

II. DISTRIBUTION IN BRITAIN.

Although this memoir is, strictly speaking, only concerned with the Pleistocene Canidæ, when the range of a species extends into other strata, whether pre- or post-Pleistocene, brief reference must be made to such remains as occur.

THE WOLF (*Canis lupus*²).

The oldest British formation in which the remains of the wolf have been found is the Red Crag. Owen,³ in 1856, first noted their occurrence in British Pliocene deposits, describing certain teeth from Woodbridge, which he attributed, with some hesitation, to this species. Newton⁴ (1891) described two canine teeth from the Red Crag of Boyton, which he believed to be those of the wolf. Owen also identified a humerus from the Forest Bed, but Newton remarks that it is very doubtful whether there is evidence of the wolf being represented at this horizon. The bone in question is now preserved in the Museum of the Geological Survey at Jermyn Street, London. These scanty records comprise the whole evidence for the occurrence of the wolf in Britain in pre-glacial times.

During Pleistocene times, however, wolves abounded throughout England, their remains having been found in nearly every bone-cave of this period (see list, p. 10) and in many river deposits,⁵ etc.

There have been comparatively few records of the wolf from Scotland, this probably being largely due to the lack of caves and deposits suitable for the preservation of the bones. This explanation will not, however, account for the scarcity and generally fragmentary condition of the wolf-bones found in Ireland. Fragmentary bones were recorded by Adams⁶ from the Shandon Cave, where they were associated with the Mammoth and were clearly of Pleistocene age, and in

¹ 'Vierteljahrschr. Ges. Zürich,' xlviii.

² It has been thought desirable, following Flower and Lydekker ('An Introduction to the Study of Mammals, Living and Extinct,' p. 546), to include wolves, jackals, dogs, and foxes in the old comprehensive genus *Canis*.

³ 'Quart. Journ. Geol. Soc.,' xii, 1856, p. 227.

⁴ 'Vertebrata of the Pliocene Deposits of Britain,' p. 8.

⁵ The lengthy account of the wolf in Harting's 'Extinct British Animals' is mainly concerned with its distribution in historic times.

⁶ 'Trans. Roy. Irish Acad.,' xxvi (Sci.) (1879), p. 221.

recent years they have been recorded by Scharff¹ from the prehistoric caves of Edenvale, co. Clare, and from those of Kesh, co. Sligo, which yielded remains referable in all probability to both the Pleistocene and Prehistoric periods.

Bones of the wolf have also been found in Prehistoric deposits at Knockninny² and Knockmore,³ co. Fermanagh, and bones somewhat doubtfully referable to the wolf at Ballynamindra,⁴ co. Waterford; but with these exceptions no wolf-bones have been recorded from Irish Prehistoric deposits, a somewhat remarkable fact in view of its great abundance in Ireland in historic times.⁵

THE DOG (*Canis familiaris*).

Owing to the frequent references to the bones of dogs in various papers dealing with the Irish Mammalian remains some allusion must be made to them here, though it is at least doubtful whether any animal that could be called a dog existed in the British Isles in Pleistocene times.

Owen⁶ admits the dog to the number of his British fossil mammals, but does not describe any British specimens. The dog is not included by Dawkins⁷ in his table showing the distribution of British post-glacial mammals, and is not mentioned by Lydekker in his 'Catalogue of the Fossil Mammalia in the British Museum.' Woodward and Sherborn⁸ admit it among the British fossil vertebrates, but (?) Prehistoric deposits at Norwich and Walthamstow are the only occurrences in Great Britain to which they allude. Skulls attributed as a rule, owing to the length and slender character of the muzzle, to the large extinct Irish wolf-hound, have been repeatedly referred to by writers on Irish mammals. Wilde⁹ (1859) described examples from near Dunshaughlin, co. Meath; Haughton¹⁰ (1876) referred to the occurrence of the dog in Knockninny cave near Lough Erne; Adams¹¹ (1880) and Ball¹² (1885) referred to the skulls described by Wilde, and agreed with him in attributing them to dogs; and Adams¹³ (1881) described slender mandibles from

¹ 'Trans. Roy. Irish Acad.,' xxxii, B., pt. 4 (1903), p. 201, and xxxiii, B., pt. 1 (1906), p. 43.

² 'Proc. Roy. Irish Acad.' (2), ii (Sci.), 1876, p. 482.

³ 'Trans. Roy. Dublin Soc.' (2), iii, 1885, p. 335.

⁴ Ibid. (2), i, 1881, p. 205.

⁵ See Adams, 'Proc. Roy. Irish Acad.' (2), iii, 1878, p. 99; and Scouler, 'Journ. Geol. Soc. Dublin,' i, 1838, p. 225.

⁶ 'Brit. Foss. Mammals and Birds,' p. 133.

⁷ 'Quart. Journ. Geol. Soc.,' xxv, 1869, p. 192.

⁸ 'A Catalogue of British Fossil Vertebrata,' 1890, p. 324.

⁹ 'Proc. Roy. Irish Acad.,' vii, 1859, p. 194.

¹⁰ Ibid. (2), ii (Sci.), 1876, p. 482.

¹¹ 'Sci. Proc. Roy. Dublin Soc.,' ii, 1880, p. 66.

¹² 'Trans. Roy. Dublin Soc.' (2), iii, 1885, p. 340.

¹³ Ibid. (2), i, 1881, p. 205.

Ballynamindra cave, co. Waterford, which he attributed to the Irish wolf-hound. There can be little doubt that all these are of post-Pleistocene date, and belong to the Prehistoric period.

Numerous bones, clearly of dogs, have been found in peat and other Prehistoric deposits in many parts of Great Britain, especially in the alluvium of the lower part of the Thames valley.

THE FOX (*Canis vulpes*).

The occurrence of the fox in the Red Crag is well authenticated, a well-preserved palate from Boyton in Suffolk having been figured and described by Lydekker.¹ He gives measurements showing that its size considerably exceeds that of a full-grown recent specimen, but in spite of this concludes that the specimen is to be referred to the fox—an opinion in which he is supported by Newton.

The evidence for the occurrence of the fox in the Forest Bed is not very good. It is based on part of a humerus which Newton² hesitated to refer to the fox. Lydekker, however, thought that the specimen was correctly referred to this species.

From Pleistocene times onwards the distribution of the fox throughout the British Isles has been practically universal. In the cavern deposits its distribution shows a remarkable correspondence with that of the wolf (see Table, p. 10).

THE ARCTIC FOX (*Canis lagopus*).

As yet the remains of the Arctic fox have been recognised at only a very few localities in Britain. The earliest record is that of Busk³ (1875), who found among the bones from the rock fissures of the Creswell Crags an axis vertebra which he carefully described and figured, referring it to the Arctic fox on account of (1) its small size; (2) the slenderness and abrupt divergence of the transverse processes; (3) the prominence of the median keel on the ventral surface of the centrum; (4) a difference in the form of the anterior articular facets from those in the common fox.

The second record is by Newton,⁴ from the Ightham fissure near Maidstone. Newton figured and ascribed to the Arctic fox a femur, a tibia, a humerus, a mandibular ramus, and part of the upper jaw. Many other bones of the Arctic fox from the same locality are in the collections of Dr. F. Corner, of Poplar, and

¹ 'Geol. Mag.,' dec. iii, i, 1884, p. 443.

² Ibid., dec. ii, vii, 1880, p. 152.

³ 'Quart. Journ. Geol. Soc.,' xxxi, 1875, pp. 685—687.

⁴ Ibid., l, 1894, p. 202, pl. xii, figs 5—9.

Mr. W. J. Lewis Abbott, of St. Leonard's (see Pls. V and VI, and Text-figs. 1—7). In the same paper by Newton a reference is made to a skull belonging to Dr. H. P. Blackmore, of Salisbury, who obtained it in 1875 from the brick earth of Fisherton, near Salisbury, where it was associated with the following Arctic animals¹: *Lepus variabilis* (the mountain hare), *Microtus nivalis*, *Myodes torquatus* (the lemming), *Ovibos moschatus* (the musk ox), and *Rangifer tarandus* (the reindeer). The reindeer was also found associated with the Arctic fox at Creswell Crags and Ightham, and Newton² is further of opinion that certain vertebræ and other bones from a small cave at Walton near Clevedon are to be attributed to the Arctic fox; here the presence of another arctic animal, the lemming, is indicated. The only record of the occurrence of the Arctic fox in Ireland is contained in Scharff's³ account of the Newhall cave, Edenvale, co. Clare, where a jaw clearly to be attributed to this species was met with. Here again it was associated with the reindeer and lemming.

SKELETAL DIFFERENCES BETWEEN THE COMMON AND ARCTIC FOXES.

The common fox is, as a rule, very considerably larger than the Arctic fox, but as small individuals may occur this difference is not always a safe criterion. There are, however, many differences in the skull. The skull of the common fox is the larger, and has the length of the jaws relatively greater in proportion to the size of the cranium, and hence the anterior premolars are more widely spaced than in the Arctic fox. On the other hand, the cranium of the common fox is somewhat narrower in proportion to its length than that of the Arctic fox, especially just behind the post-orbital processes. These tend to be longer in the common fox than in the Arctic fox. Scharff mentions that the length of m. 2 is somewhat greater in the common fox than in the Arctic fox, but this difference seems scarcely appreciable in the British Museum specimens.

? *Lycaon anglicus*, Lyd.

This name is applied by Lydekker⁴ to a left mandibular ramus from the Spritsail Tor cave, Gower, which was originally described and figured by Falconer⁵ under the name of "hyænoid wolf." The specimen was subsequently fully des-

¹ "The Geology of the Country around Salisbury," 'Mem. Geol. Surv. of England and Wales,' 1903, p. 68.

² 'Proc. Bristol Nat. Soc.,' 4th ser., i, pt. 3, p. 186, 1907 (issued for 1906).

³ 'Trans. Roy. Irish Acad.,' xxxiii, B., pt. 1, p. 48.

⁴ 'Geol. Mag.,' dec. iii, i, 1884, p. 443.

⁵ 'Pal. Mem.,' ii, pl. xxxvi, figs. 1, 2.

cribed by Lydekker¹ in his 'Catalogue of the Fossil Mammalia in the British Museum.' The feature upon which he principally relies in the attribution of this specimen to the genus *Lycaon* is the presence of a "distinct anterior talon" to the fourth premolar. There is no doubt that an anterior cusp is very distinctly present in this specimen (see Pl. V, figs. 7, 8); and in a large series of wolf-skulls in the British Museum no specimen was found showing any comparable development, though in certain cases, *e. g.* the skull of a wolf from Kandahar (168a) and a North American example (165d), slight indications of an anterior cusp occur. But on the other hand pm. 2 and 3 of the Spritsail Tor specimen are identical with those of the wolf, being considerably longer in proportion to the height of the crown than are the corresponding teeth in any of the skulls of *Lycaon* examined in the British Museum; pm. 4, too, agrees precisely in the characters of its main lobe and posterior cusps with the corresponding tooth of the wolf, and differs considerably from the *Lycaon* type. In view of the known variability in the teeth of Canidæ and of the difficulties of geographical distribution involved in the addition of a southern form like *Lycaon* to the British faunal list, it seems the most satisfactory course, on the whole, to regard the Spritsail Tor specimen as a somewhat abnormal wolf.

TABLE SHOWING DISTRIBUTION OF BRITISH PLEISTOCENE CANIDÆ IN RIVER DEPOSITS, ETC.

	Wolf.	Fox.	Arctic Fox.
Beilbecks, Yorks	×
Bracklesham, Sussex	×
Crayford	×
Dartford	×	...
Fisherton, Salisbury	×	×	×
Grays	×	×	...
Ilford	×
Ipswich.....	×	×	...
Murston, Sittingbourne	×
Newbury	×
Slade Green, near Erith	×
Tewkesbury	×
Thame	×
Weston-s.-mare	×	...
Windsor	×

¹ 'Catalogue of the Fossil Mammalia in the British Museum,' pt. i, p. 122, 1885.

TABLE SHOWING DISTRIBUTION OF BRITISH PLEISTOCENE CANIDÆ IN CAVERNS.

	Wolf.	Fox.	Arctic Fox.
Anstey's Cave, Torquay.....	...	×	...
Bacon Hole, Gower	×	×	...
Banwell	×	×	...
Bench Cave, Brixham	×	×	...
Bleadon	×	×	...
Bosco's Hole, Gower	×	×	...
Cae Gwyn, Clwyd Vale	×
Caswell Bay, Gower	×	...
Cefn, near St. Asaph	×
Creswell Crags, Derbyshire	×	×	×
Crow Hole, Gower	×	×	...
Deborah Den, Gower	×
Ffynnon Beuno, Clwyd Vale.....	×	×	...
Durdham Down	×	×	...
Hoe Grange, near Longcliff, Derbyshire	×	×	...
Hutton	×	×	...
Ightham Fissure near Maidstone.....	×	×	×
Kent's Cavern, Torquay	×	×	...
Kirkdale	×	×	...
Langwith Bassett, near Mansfield	×	×	...
Long Hole, Gower	×	×	...
Minchin Hole, Gower.....	×	×	...
Oreston	×	×	...
Paviland, Gower	×	×	...
Pleasley Vale, Derbyshire	×
Ravenscliff, Gower	×	×	...
Sandford	×	×	...
Shandon Cave, Dungarvon	×	×	...
Spritsail Tor, Gower	×	×	...
Teesdale	×
Torbryan, Torquay.....	×	×	...
Uphill	×	×	...
Walton, near Clevedon	×	×	×
Waterhouses, Staffordshire	×
Windy Knoll, Castleton	×	×	...
Wookey Hole	×	×	...
Yealm Bridge	×	×	...

III. DESCRIPTION OF THE REMAINS.

The Canidæ¹ comprise the only family of the section Cynoidea, the second of the three into which the Carnivora Vera are divisible. With regard to the dentition they show less specialisation than any other group of living Carnivora, and in other respects approach relatively near to the primitive type. The structure of the auditory bulla and adjacent parts of the skull is intermediate in character between that of the Æluroidea and that of the Arctoidea, as the Cynoidea agree with the Æluroidea in having the auditory bulla inflated and the paroccipital process of the

¹ See Flower and Lydekker, 'Mammals, Living and Extinct,' p. 544, *et seq.*

exoccipital in contact with it, while they agree with the Arctoidea in the almost complete absence of a septum dividing the auditory bulla, in the large size of the glenoid foramen, and in the presence of an alisphenoid canal. In the living forms there is no entepicondylar foramen. The upper molars have a triangular crown, and the blade of the upper carnassial consists of two lobes.

A. THE SKULL (Plates I—IV).

The cranium is moderately elongated, the jaws long, tapering, and somewhat compressed. The zygomatic processes of the frontal and malar are short, so that the orbit communicates widely with the temporal fossa. The pterygoid has a well-developed hamular process. The auditory meatus forms a short but fairly prominent bony tube.

The following are characters upon which most stress has been laid in attempting to discriminate between the skulls of wolves, dogs and foxes :

- (1) The relative proportions of the jaws and cranium ;
- (2) The extent to which the temporal ridges, always widely separate in young animals, approach and coalesce into a sagittal crest in the adult ;
- (3) The greater or less backward extension of the nasals ;
- (4) The character of the post-orbital process of the frontal ;
- (5) The union of the nasal processes of the frontals with the ascending processes of the premaxillæ, or the separation of these processes from one another by the meeting of the maxillæ and nasals ;
- (6) The length of pm. 4 as compared with that of m. 1 and 2 taken together ;
- (7) The orbito-frontal angle or the obliquity of the opening of the orbit to the brow.

B. DENTITION (Plate V).

(1) *Distinctive Features of the Teeth in the Genus Canis*.—The typical dental formula is i. $\frac{3}{3}$, c. $\frac{1}{1}$, pm. $\frac{4}{4}$, m. $\frac{2}{3}$, as in *Ursus*, but in aberrant forms (*Cyon*) the molars are $\frac{2}{2}$, and in a fossil form, *Canis (Lycorpus) nemesianus*, the premolars are $\frac{4}{3}$. Further, in *Canis cancrivorus* the missing last upper molar is occasionally present. The formula embracing these variations is i. $\frac{3}{3}$, c. $\frac{1}{1}$, pm. $\frac{4}{3-4}$, m. $\frac{2-3}{2-3}$.

The contrast in size between the canine and incisor teeth is not so great as in either cats or bears. The upper carnassial tooth, pm. 4, differs from that in bears, and resembles that in cats and hyænas in possessing an antero-internally placed inner tubercle supported by a distinct root.

In accordance with the method adopted in previous memoirs it has been

(1) TABLE OF COMPARATIVE MEASUREMENTS OF CANINE SKULLS.

	<i>C. lupus</i> , recent, Yesso, Mus.). No. 86.11.18.1. (Brit.	<i>C. lupus</i> , Pleistocene, Kent's Cave, Torquay (Torquay Mus.).	<i>C. lupus</i> , Pleistocene, Banwell Cave, No. 44640 (Brit. Mus.).	<i>C. lupus</i> , Pleistocene, Hutton Cave, No. 44739a (Brit. Mus.).	<i>C. sp.</i> , Prehistoric, peat, Denver, Norfolk (Sedgwick Mus.).	<i>C. familiaris</i> , Prehistoric, turbary, Walthamstow, No. 41439 (Brit. Mus.).	<i>C. familiaris</i> , Prehistoric, Bawdsey bog, Suffolk, No. 27508 (Brit. Mus.).	<i>C. vulpes</i> , recent, Villa- marque, No. 93.9.4.7 (Brit. Mus.).	<i>C. vulpes</i> , Prehistoric, peat, Newbury, No. 44777 (Brit. Mus.).	<i>C. vulpes</i> , Pleistocene, Ightham, near Maidstone (Lewis Abbott Coll.).	<i>C. lagopus</i> , recent, Kam- skatchka, No. 88.2.20.8 (Brit. Mus.).	<i>C. lagopus</i> , Pleistocene, Ightham, near Maidstone (Lewis Abbott Coll.).
1. Length from intercondylar notch to anterior end of skull	23.6	22.0*	21.3*	20.9*	21.65	17.1	16.8	14.4	14.5	12.35*	12.2*	10.1*
2. Extreme width across zygomatic arches	15.05	...	...	12.5	13.15	10.65	11.55	8.4	9.0	...	7.25	7.2
3. Vertical height from suture between basi-occipital and basi-sphenoid to top of sagittal crest	7.3	7.55	7.35	6.7	6.6	6.45	5.9	4.1	4.9	4.6	3.9	3.45
4. Width at lachrymal foramen	5.8	5.8	4.85	...	5.45	4.75	4.4	3.5	3.55	3.05	3.2	2.6
5. Width between ends of post-orbital processes of frontal	6.75	6.35	4.8	5.6	7.15	4.95	5.8	4.0	4.6	3.55	3.5	2.95
6. Width below foramen lacerum antierius	1.15	1.18	...	1.1	1.2	1.25	1.5	.9	.95	.85	.85	.65
7. Transverse measurement across occipital condyles	4.55	4.85	4.5	4.2	4.6	3.9	3.9	2.7	3.1	2.6	2.5	2.2
8. Transverse measurement across external auditory meatus	7.7	...	6.7	7.2	7.4	6.0	6.3	4.25	4.7	4.4	4.2	3.7
9. Transverse diameter of foramen magnum	2.3	2.05	...	...	1.95	2.0	1.8	1.6	1.65	1.5	1.5	1.3
10. Length of palate	13.2	12.85	...	...	...	9.8	9.65	8.1	...	6.8	6.7	5.6
11. Orbito-frontal angle	40+	...	42+	45+	53+	48+	47+	...	...	...	...	...
12. Maximum length of mandibular ramus measured to end of condyle	20.55	...	...	17.4	18.1	12.3	...	11.7	9.8*	8.15*+	9.55	...
13. Height from angle to top of coronoid process	8.05	...	...	...	7.25	4.2	...	4.0	3.5	3.2	3.7	...

* Figured.

+ It is uncertain whether these mandibles belong to the crania.

Note.—All measurements are given in centimetres.

thought best when describing the teeth not to use terms involving assumptions of homology and requiring long explanatory prefixes. The terms "cusp" and "tubercle" are regarded as synonyms for small elevations of the surface of a tooth. The term "cone" is used as denoting a rather larger elevation, and the terms "talon" or "heel" for posteriorly-placed segments of a tooth.

(2) *Permanent Dentition of the Upper Jaw in Canis lupus* (Pl. V).—In drawing up the following description, the skulls and teeth of a number of wolves, recent and fossil, now preserved in the British Museum have been examined, but the principal part of the description is based on a skull of a male wolf from Pekin, No. 90.7.8.2 in the British Museum collection.

I. 1 and 2 are very similar teeth, differing only in the slightly larger size of i. 2. The principal cone is somewhat recurved and there are small laterally-placed accessory cusps. The cingulum is rather strongly marked. In some cases the lateral accessory cusps are scarcely noticeable, but the cingulum is raised into slight cusps posteriorly. The root is about three times as long as the crown and is much laterally compressed.

I. 3 is a rather larger and more caniniform tooth than i. 1 and 2 and shows some variability, the postero-internal face being sometimes marked by a cingulum, sometimes raised into a pair of laterally-placed cusps. The root is about twice as long as the crown and is triangular in cross-section, not laterally compressed as in i. 1 and 2.

C. The canine has the form usual in the Carnivora. Its crown constitutes about two thirds of its length.

Pm. 1 is a small, single-rooted tooth with a fairly well-marked cingulum surrounding the principal cone. Very slight accessory cusps may be developed on the cingulum posteriorly and antero-internally.

Pm. 2 is a larger and more elongated two-rooted tooth with a conical crown triangular in outline. A posteriorly-placed cusp may be present or absent.

Pm. 3 closely resembles pm. 2, differing only in its larger size and in the greater prominence of the posterior cusp, which may be double.

Pm. 4, the upper carnassial, is a large three-rooted tooth with a powerful trenchant blade divided into an anterior more conical portion and a posterior portion with a chisel-like edge. Placed anteriorly is a low inner tubercle supported by a distinct root.

M. 1. This is a large tooth, somewhat wider than long. The outer portion of the crown is formed by two prominent cones of which the anterior is the larger; the inner portion of the tooth is much depressed, but the inner edge is raised into a more or less prominent ridge and two low cusps lie between this and the outer portion of the tooth. Two roots support the outer portion, and a third and stouter root the inner portion.

M. 2 is a considerably smaller tooth than m. 1 but is constituted on the same plan, having two relatively prominent cones or cusps on the outer part of the tooth, and a depressed inner area bearing several slight cusps. Two roots support the outer portion of the tooth, a third and larger root the inner portion.

(3) *Permanent Dentition of the Lower Jaw of Canis lupus* (Pl. V).—I. 1, 2 and 3 are all very similar teeth, differing only by their progressive increase in size, and in the fact that while i. 1 and 2 have the root strongly laterally compressed i. 3 has it more or less triangular in section. Each tooth has a somewhat chisel-shaped edge with a small accessory cusp placed externally to the main cone.

C. This tooth is of the usual type and differs from c. only in the fact that the inner border tends to be rather more sharply curved.

Pm. 1, which is sometimes wanting, is a small single-rooted tooth with a simple conical blade, bearing, as a rule, a very slight cusp posteriorly placed.

Pm. 2, 3, 4 are very similar two-rooted teeth each with a triangular blade, which in pm. 3 and 4 may be slightly recurved. There is a slight cusp posteriorly placed in pm. 2, and this becomes larger in pm. 3 and 4. The cingulum is well marked on the inner surface of the teeth, and in pm. 3, and more often in pm. 4, may give rise to a second posteriorly-placed cusp. In some cases each of these teeth bears a slight cusp anteriorly placed.

M. 1. This is a large tooth supported by two stout roots. The anterior two thirds is formed by the powerful bilobed blade, the posterior lobe being slightly the larger and having a small cusp placed postero-internally. The last third of the tooth forms a depressed talon or heel and bears two cusps placed side by side, the outer one being somewhat the larger.

M. 2 is a rather small, somewhat oblong tooth supported by two roots. The anterior part of the crown bears a pair of cusps placed side by side, while a third cusp lies postero-externally. In some cases there are indications of a fourth cusp placed postero-internally.

M. 3 is a very small one-rooted tooth with a nearly oval crown bearing one or more slight cusps.

(4) *Milk or Deciduous Dentition* (Pl. V).¹—The formula for this is d.i. $\frac{3}{3}$, d.c. $\frac{1}{1}$, d.m. $\frac{3}{3} = 28$.

The first permanent premolar has no milk predecessor.

(A) *Milk Dentition of the Upper Jaw*.—D.i. 1, 2 and 3. These are all small and extremely simple teeth with short crowns and long, somewhat tapering roots.

D.c. is a reduced representative of the permanent tooth and requires no special description.

¹ The description is drawn up from a made-up set of milk-teeth of *Canis ? lupus* from Torbryan, Torquay, now in the British Museum.

D.m. 1 is a good deal like pm. 2, the blade having a principal cone and often a slight posteriorly-placed accessory cusp. The two teeth differ, however, in the fact that d.m. 1 has the roots strongly divergent.

D.m. 2, the milk carnassial, is the largest of the deciduous teeth. The major portion of the crown is formed by a powerful bilobed blade, of which the anterior lobe is conical, the posterior more depressed and chisel-like. In front of the blade are two low cusps. There is further a prominent inner cusp anteriorly placed. This is supported by a special root, and two other strong roots support the outer part of the tooth.

D.m. 3 is a very irregular tooth. The outer edge, which bears certain ill-defined cusps, is raised anteriorly and supported by a small root, while posteriorly it is depressed and supported by a strong triangular, divergent root. There is an inner cusp supported by a third root.

(B) *Milk Dentition of the Lower Jaw.*—D.i. 1, 2 and 3. These are even slighter and simpler teeth than those of the upper jaw, and have very long, tapering roots.

D.c. This is practically identical in character with that of the upper jaw.

D.m. 1.—Except for its smaller size and the more divergent character of the roots, this is identical with pm. 2.

D.m. 2 very closely resembles pm. 3, but the accessory cusp anterior to the principal cone is better developed than in that tooth.

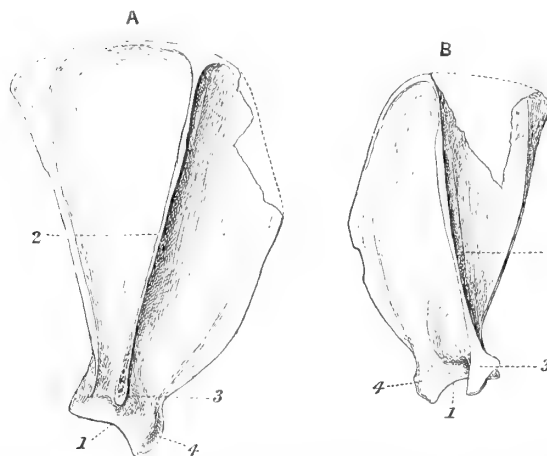
D.m. 3, the milk carnassial, is a large tooth supported by two strong divergent roots. Four fifths of the crown is formed by a bilobed trenchant blade, and behind this is a considerable cusp.

C. THE VERTEBRAL COLUMN (Plate VI).

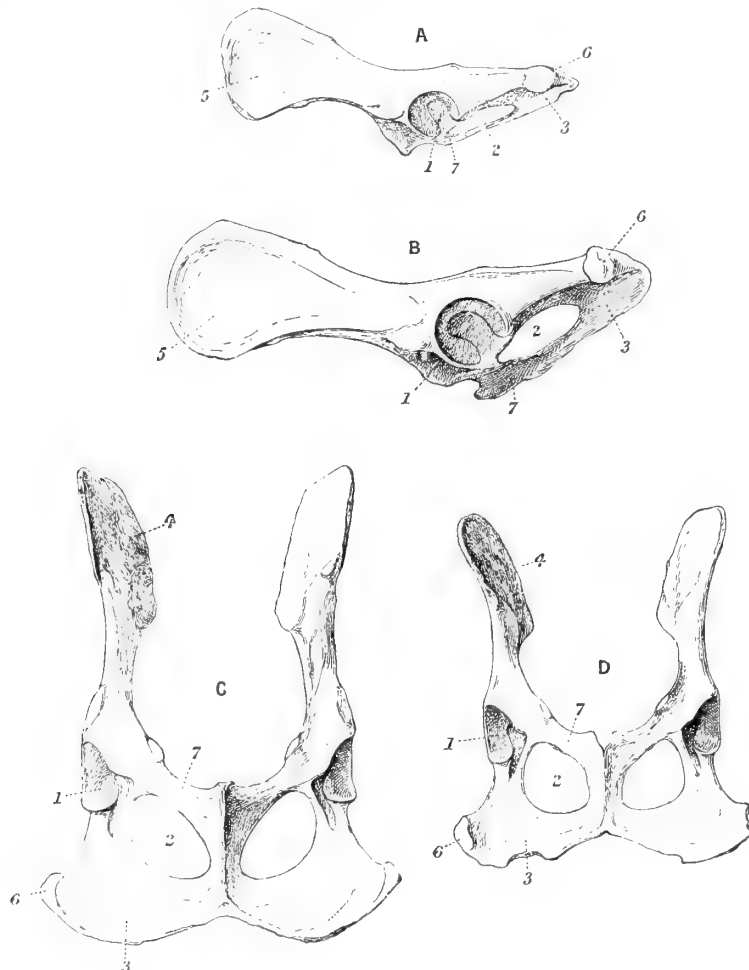
Little or nothing can be mentioned as specially characteristic of the vertebral column in the Canidæ in comparison with that in other Carnivora, but the variable number of the caudal vertebræ may be alluded to, the number ranging from seventeen to twenty-two. There are thirteen thoracic and seven lumbar vertebræ. Only three vertebræ are fused together in the sacral region, while in bears the number may be as many as five.

D. THE LIMB GIRDLES.

The Shoulder Girdle.—The scapula (Text-fig. 1) scarcely calls for special comment, though it may be mentioned that the coracoid process is very slightly developed. The British fossil specimens are almost always in a very fragmentary condition. The clavicle is in a much reduced state, though better developed than in bears.



TEXT-FIG. 1.—A. Right scapula of a common fox (*Canis vulpes*) seen from the outer side. B. Left scapula of an Arctic fox (*Canis lagopus*) seen from the outer side. Both from Ightham (Lewis Abbott Coll.). $\frac{2}{3}$ natural size. 1, glenoid cavity; 2, spine; 3, acromion; 4, coracoid process.



TEXT-FIG. 2.—A. Pelvic girdle of an Arctic fox (*Canis lagopus*) seen from the left side. B. Pelvic girdle of a common fox (*Canis vulpes*) seen from the left side. C. Pelvic girdle of a common fox (*Canis vulpes*) seen from below. D. Pelvic girdle of an Arctic fox (*Canis lagopus*) seen from below. The Arctic fox is from the Pleistocene of Ightham near Maidstone (Lewis Abbott Coll.), the common fox from the Prehistoric alluvium of the Thames Valley, Walthamstow (Brit. Mus.). $\frac{2}{3}$ natural size. 1, acetabulum; 2, obturator foramen; 3, ischium; 4, sacral surface of ilium; 5, gluteal surface of ilium; 6, ischial tuberosity; 7, pubis.

(2) TABLES OF COMPARATIVE MEASUREMENTS OF THE LIMB GIRDLES.

Table of measurements of the scapula.	<i>C. vulpes</i> , Pleistocene, Ightham, near Maidstone. (Lewis Abbott Coll.)	<i>C. lagopus</i> , Pleistocene, Ightham, near Maidstone. (Lewis Abbott Coll.)
1. Maximum length	8.25*	6.45*
2. Maximum width	—	3.25
3. Minimum width at the neck	1.7	1.3
4. Width at proximal end measured to end of coronoid process	1.9	1.45
5. Height from top of acromion to inner edge of glenoid cavity.....	—	1.8

Table of measurements of the pelvic girdle.		
1. Maximum length	9.3	7.0
2. Length from acetabulum to supra-iliac border of ilium	5.5	4.0
3. Dorso-ventral measurement of ilium at widest point	3.15	2.1
4. Antero-posterior diameter of acetabulum ...	1.45	1.1
5. Length from acetabulum to posterior border of ischium	—	2.35
6. Maximum diameter of obturator foramen...	2.15	1.6
7. Measurement along ischium from symphysis to end of ischial spine	3.8	3.1

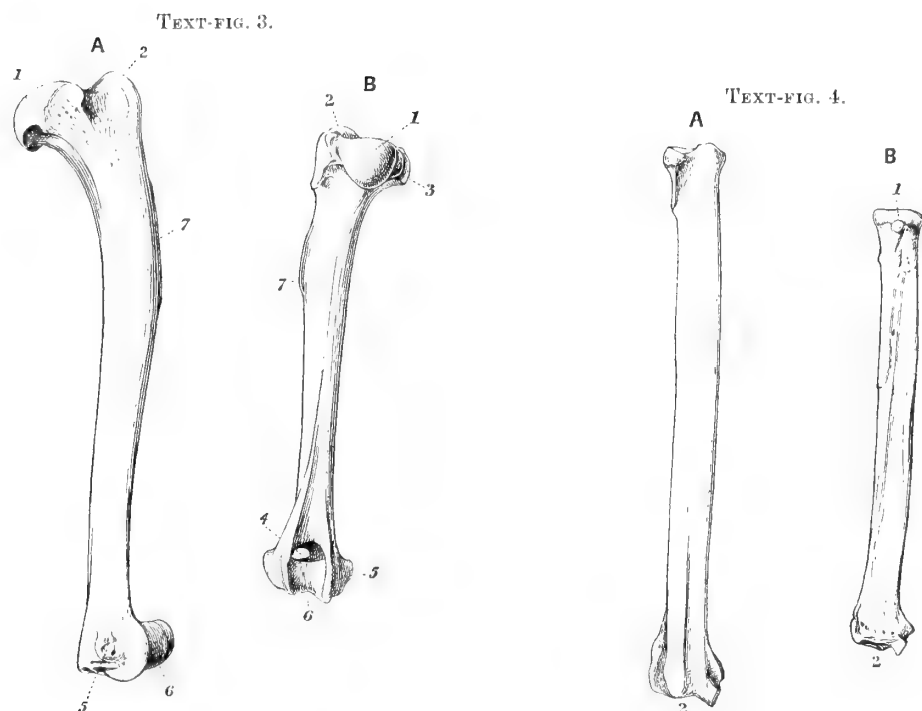
* Figured.

(2) *The Pelvic Girdle*.—This (Text-fig. 2) does not present any specially characteristic features.

E. THE LIMBS.

These are of moderate length, and agree with those of the Felidæ and differ from those of the Ursidæ in being strongly digitigrade. All the digits are terminated by non-retractile claws.

(1) *The Anterior Limb*.—The humerus (Text-fig. 3) is rather short. There is no entepicondylar foramen, but a supra-trochlear foramen is always present. The metacarpals are longer and more curved than in *Felis*. Five digits are present, but the pollex is much shorter than the others and does not reach the ground.



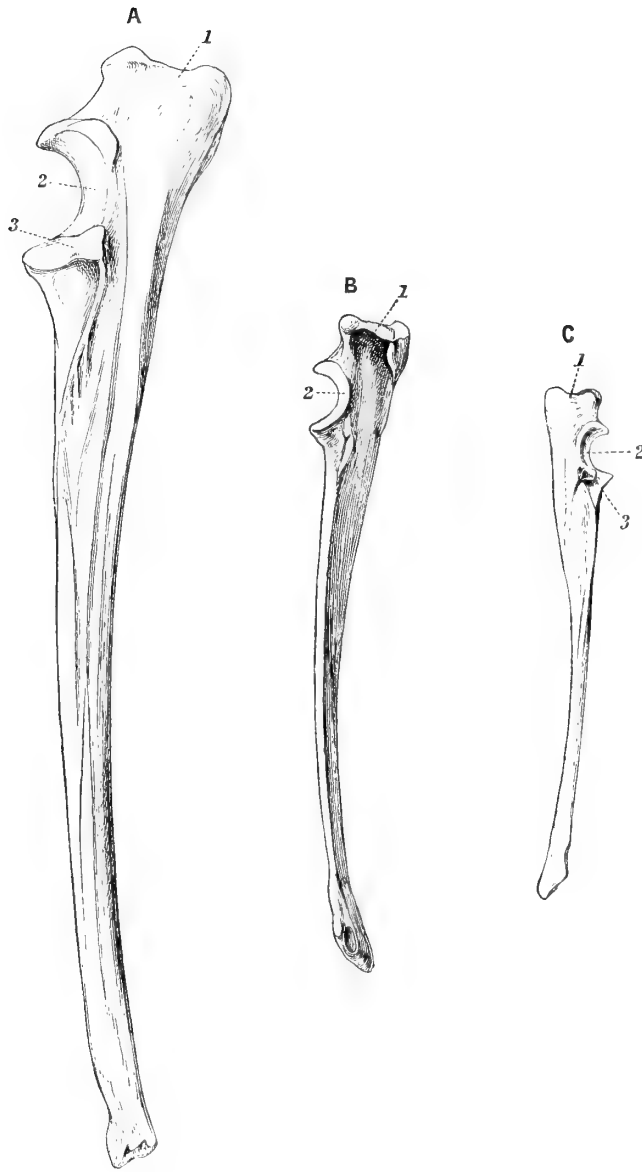
TEXT-FIG. 3.—A. Left humerus of a common fox (*Canis vulpes*) seen from the inner side. B. Left humerus of an Arctic fox (*Canis lagopus*) seen from behind. Both from Ightham (Corner Coll.). $\frac{2}{3}$ natural size. 1, head; 2, greater tuberosity; 3, lesser tuberosity; 4, supra-trochlear foramen; 5, internal condyle; 6, trochlea; 7, deltoid ridge.

TEXT-FIG. 4.—A. Right radius of a common fox (*Canis vulpes*) seen from front. B. Left radius of an Arctic fox (*Canis lagopus*) seen from behind. Both from Ightham (Brit. Mus., No. M.7232, and Corner Coll.). $\frac{2}{3}$ natural size. 1, surface for articulation with ulna; 2, surface for articulation with carpus.

(3) TABLE OF COMPARATIVE MEASUREMENTS OF BONES OF ANTERIOR LIMB.

Humerus.	<i>C. lupus</i> (left). Pleistocene. Banwell. No. 44640 (Brit. Mus.).	<i>C. vulpes</i> (left). Pleistocene. Ightham, near Maidstone. (Corner Coll.)	<i>C. lagopus</i> (left). Pleistocene. Ightham, near Maidstone. (Corner Coll.)
1. Maximum length	19.75	12.3*	9.4*
2. Diameter of proximal end passing across centre of articulating surface and greater tuberosity .....	...	2.6	1.9
3. Antero-posterior diameter of shaft at middle of deltoid ridge	2.5	1.15	1.0
4. Transverse diameter at same point	1.75	0.8	0.7
5. Maximum transverse diameter at distal end	4.4	2.1	1.7

* Figured.



TEXT-FIG. 5.—A. Left ulna of a wolf (*Canis lupus*), incomplete at distal end, seen from the left side. From Kent's Cavern, Torquay (Brit. Mus., No. M.830). B. Right ulna of a common fox (*Canis vulpes*) seen from the left side. From Ightham (Brit. Mus., No. M.7232). C. Right ulna of an Arctic fox (*Canis lagopus*) seen from the right side. From Ightham (Lewis Abbott Coll.). $\frac{2}{3}$ natural size. 1, olecranon; 2, surface for articulation with the trochlea; 3, surface for articulation with the radius.

(3) TABLE OF COMPARATIVE MEASUREMENTS OF BONES OF ANTERIOR LIMB—*continued*.

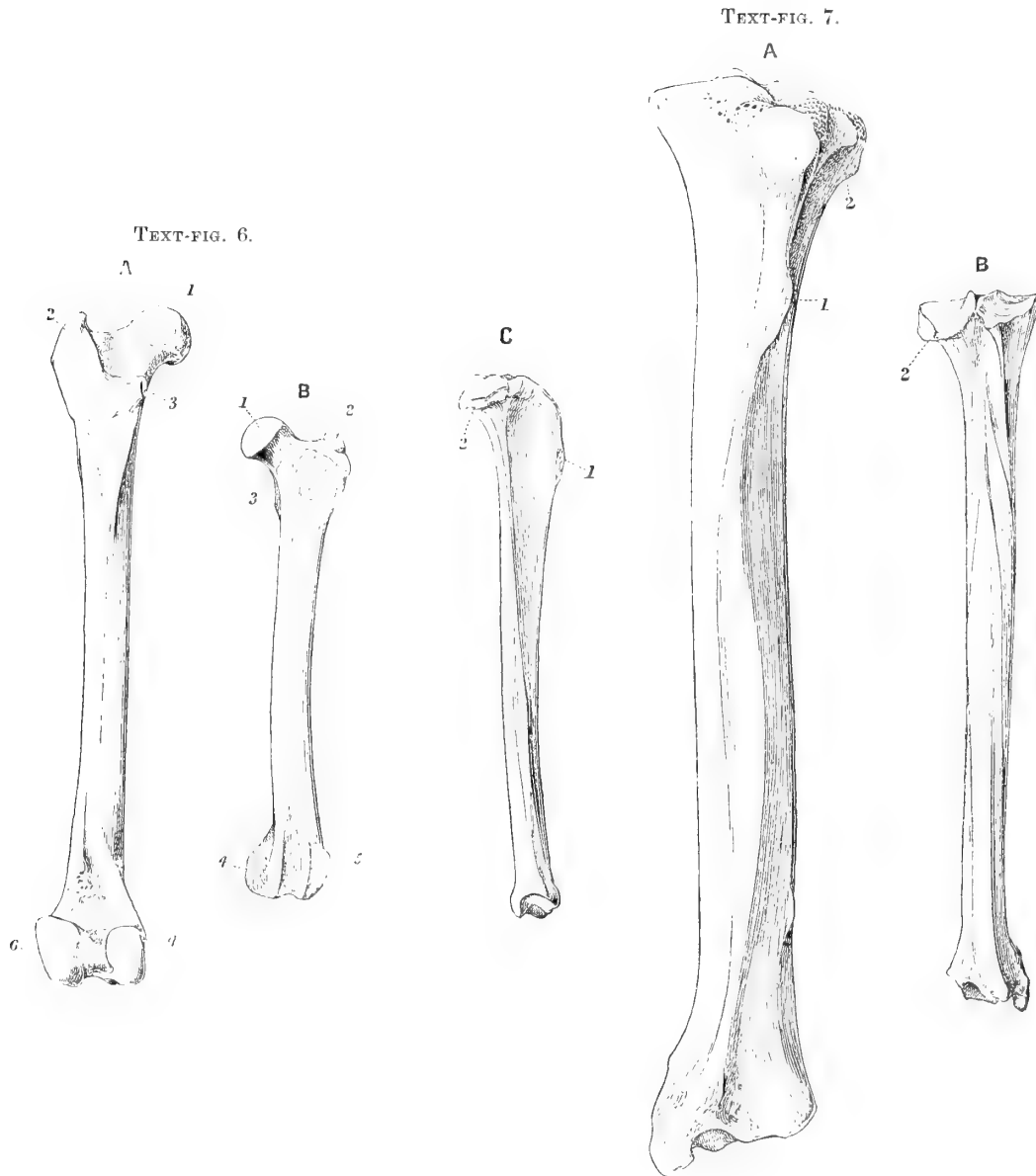
Radius.	<i>C. lupus</i> (left). Pleistocene. Ightham, near Maidstone. (Corner Coll.)	<i>C. vulpes</i> (right). Pleistocene. Ightham, near Maidstone. No. M.7232 (Brit. Mus.).	<i>C. lagopus</i> (left). Pleistocene. Ightham, near Maidstone. (Corner Coll.)
1. Maximum length	18.15	11.05*	8.7*
2. Shorter, <i>i. e.</i> right to left, diameter at humeral articulation	1.4	0.75	0.6
3. Longer, <i>i. e.</i> antero-posterior, diameter at humeral articulation	2.4	1.15	0.95
4. Shorter, <i>i. e.</i> right to left, diameter at carpal articulation	1.6	0.75	0.6
5. Longer, <i>i. e.</i> antero-posterior, diameter at carpal articulation	3.05	1.45	1.2
Ulna.	<i>C. lupus</i> (left). Pleistocene. Kent's Cavern, Torquay. No. M.830 (Brit. Mus.).	<i>C. vulpes</i> (right). Pleistocene. Ightham, near Maidstone. No. M.7232 (Brit. Mus.).	<i>C. lagopus</i> (right). Pleistocene. Ightham, near Maidstone. (Lewis Abbott Coll.)
1. Maximum length .....	...	12.9*	10.05*
2. Antero-posterior or vertical measurement at sigmoid notch	1.9*	1.0	0.7
3. Maximum transverse measurement of olecranon	1.55	0.7	0.5

(2) *The Posterior Limb*.—The tibia (Text-fig. 7) has the crest somewhat sharply truncated. The second to fifth digits are well developed, but the hallux is absent, or vestigial and suspended in the skin without bony connection with the rest of the pes.

(4) TABLE OF COMPARATIVE MEASUREMENTS OF BONES OF POSTERIOR LIMB.

Femur.	<i>C. lupus</i> (right). Pleistocene. Ightham, near Maidstone. (Corner Coll.)	<i>C. vulpes</i> (left). Pleistocene. Ightham, near Maidstone. (Corner Coll.)	<i>C. lagopus</i> (left). Pleistocene. Ightham, near Maidstone. (Corner Coll.)
1. Maximum length	21.4	13.9*	9.9*
2. Transverse or right to left diameter at condyles	4.0	2.15	1.75
3. Antero-posterior diameter of head	2.4	1.3	1.0
4. Vertical or antero-posterior diameter of shaft at middle	1.75	0.85	0.7
5. Transverse diameter at proximal end measured across head and great trochanter	5.0	2.8	2.25

* Figured.



TEXT-FIG. 6.—A. Left femur of a common fox (*Canis vulpes*) seen from behind. B. Left femur of an Arctic fox (*Canis lagopus*) seen from front. Both from Ightham (Corner Coll.). $\frac{2}{3}$ natural size. 1, head; 2, great trochanter; 3, lesser trochanter; 4, internal condyle; 5, external condyle.

TEXT-FIG. 7.—A. Left tibia of a wolf (*Canis lupus*) seen from front. From Torbryan Cavern, Torquay (Brit. Mus.). B. Left tibia of a common fox (*Canis vulpes*) seen from behind. From Ightham (Brit. Mus., No. M.7232). C. Right tibia of an Arctic fox (*Canis lagopus*) seen from the right side. From Ightham (Lewis Abbott Coll.). $\frac{2}{3}$ natural size. 1, cnemial crest; 2, facet for articulation with fibula.

(4) TABLE OF COMPARATIVE MEASUREMENTS OF BONES OF POSTERIOR LIMB—*continued*.

Tibia.	<i>C. lupus</i> (left). Pleistocene. Torbryan, Tor- quay. No. M.4563 (Brit. Mus.).	<i>C. lupus</i> (left). Pleistocene. Ightham, near Maidstone. (Corner Coll.)	<i>C. vulpes</i> (left). Pleistocene. Ightham, near Maidstone. No. M.7232 (Brit. Mus.).	<i>C. lagopus</i> (right). Pleistocene. Ightham, near Maidstone. (Corner Coll.)
1. Maximum length	21.45*	21.7	14.3*	10.75
2. Transverse or right to left diameter at proximal end	4.4	4.4	2.45	1.85
3. Vertical or antero-posterior diameter at proximal end measured to top of crest	3.4	4.3	1.7	1.7
4. Transverse diameter at distal end	3.05	3.0	1.6	1.25
5. Vertical or antero-posterior diameter at distal end	2.3	2.05	1.1	0.85

* Figured.

IV. MUTUAL RELATIONS OF THE PLEISTOCENE AND POST- PLEISTOCENE CANIDÆ.

This most difficult subject has puzzled zoologists from the time of Buffon and Daubenton to the present day. It cannot be entirely overlooked in such a memoir as the present, but no attempt will be made to deal exhaustively with it.

Two questions are involved, which, though distinct, have the most intimate bearing upon one another.

The first of these is, whether any valid and reliable distinction can be found between the dogs, on the one hand, and the wolves and jackals on the other. The second is, whether the origin of the domestic dogs is to be sought wholly or partially in the existing wild Canidæ—wolf, jackal, or certain kinds of wild dog, or whether it may be found in one or more fossil species known or as yet undiscovered. The former of these questions may be first considered. A large number of points have been referred to by zoologists in their attempts to find valid osteological distinctions between dog and wolf. To each point in the following list the names of certain authors who allude to it are appended; but it is not implied that in every case the points are accepted as valid distinguishing characters by the authors who allude to them.

(1) Wolves have the triangular part of the cranium between the orbits a little narrower and flatter than in dogs (Cuvier, Denny).

(2) The sagittal crest is longer and more elevated in wolves than in dogs (Cuvier, Denny, Vieira).

(3) The teeth, especially the canines, are longer in wolves than in dogs (Cuvier, Denny).

(4) The length of the upper carnassial pm. 4 is superior or at least equal to that of the molars m. 1 and 2 in wolves, while in dogs the length of pm. 4 is less than, or at most equal to, that of the m. 1 and 2 (Gaudry and Boule).

(5) The plane of the eye-socket is more obliquely inclined to the brow, *i. e.* the orbito-frontal angle is less in wolves than in dogs (Studer) (see Text-fig. 8).

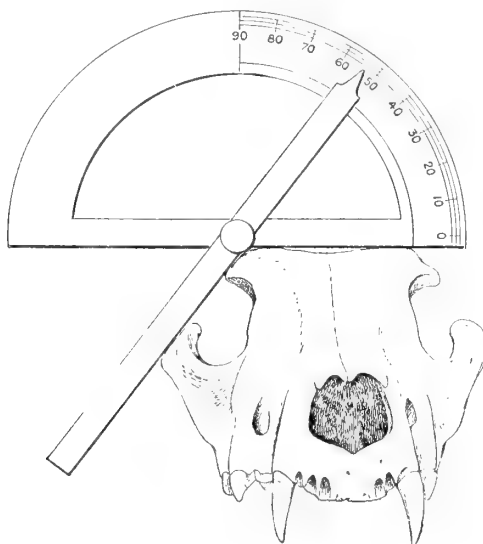
(6) The brow is more swollen at the base of the muzzle in dogs (de Blainville).

(7) The zygomatic arch is less curved and shorter in the wolf (Vieira).

(8) The coronoid process reaches above the zygomatic arch in the dog but not in the wolf (Vieira).

(9) The caudal vertebræ are more variable in the dog (de Blainville).

Denny¹ also refers to the following points: (*a*) The intermaxillaries (? nasal



TEXT-FIG. 8.—Anterior view of the skull of a dog, and instrument for measuring the orbito-frontal angle.

processes of the premaxillæ) and nasals are longer and narrower in dogs than in wolves; (*b*) the nasal cavity is wider in wolves; (*c*) the orbital projections (probably the post-orbital processes of the frontals) are more acute in dogs; (*d*) the jaws are wider; and (*e*) the tympanics are larger in wolves.

The above is a considerable list, but the great majority of the points amount to very little and are quite inconstant and unreliable.

Probably the most important character is No. 5, for which we are indebted to Studer.² The angle to which he alludes can be better realised by the preceding diagram (Text-fig. 8) than by description. He regards as belonging to wolves, skulls in which the angle between the plane of the orbit and that of the brow measures 40–45°, and as belonging to dogs, skulls in which the angle is greater

¹ 'Proc. Yorks. Geol. Polyt. Soc.,' iii, 1857 (1859), p. 538.

² 'Abh. schweiz. pal. Ges.,' xxviii, p. 13.

than 45° . The effect of this greater obliquity of the plane of the orbit in the wolf is to produce the "oblique leering eye which gives the wolf a false expression as compared with the noble, trustful expression of a dog, whose eye, with rounder opening, is more directed forwards." He remarks that if we look at a wolf's or jackal's skull from above, more of the orbit is visible than in a dog's skull.

The reliability of this distinction, which is accepted by Scharff¹ and used in discriminating the canine skulls from the Edenvale caves, has been to some extent tested by examination of skulls at the British Museum and at Bristol with the following results :

Number of specimens.	Species.	From	Maximum angle.	Minimum angle.	Average angle.
(a) 8	Wolf (recent)	Brit. Mus.	45°	40°	42°
(b) 5	Dog (prehistoric)	" "	53°	46°	$49\frac{3}{5}^\circ$
(c) 27	Dog (recent)	" "	62°	45°	$50\frac{1}{3}^\circ$
(d) 9	" "	Bristol Univ.	54°	48°	$51\frac{1}{3}^\circ$

Belonging to each of the first three groups there were, however, certain exceptional skulls which are not included in the above table. Thus two additional wolf skulls belonging to group (a) gave angles of 47° and 48° respectively, two dog skulls in group (b) had angles of 42° , three skulls in group (c) had angles below 45° .

The angle is not very easy to measure even with a clinometer such as is shown in the figure, and it was found that when the same skull was measured on different occasions slightly varying results were sometimes obtained.

The measurement was in each case taken over the ends of the post-orbital processes of the frontal and jugal.

Though it can hardly be claimed that the results of the measurement of the fifty-six skulls referred to in the above table afford a complete test of the reliability of the orbito-frontal angle as a distinguishing character between dogs and wolves, they certainly confirm Studer's contention that the angle tends to be decidedly less in the wolf than in the dog, and that it affords a useful distinction of practical value. The occurrence, however, of dog skulls with an angle of less than 45° , and of wolf skulls with an angle of over 45° , shows that the distinction is not absolute, and cannot be relied on in all cases.

The second point, that of the origin of the domestic dogs, is the subject of a most voluminous literature. It is beyond the scope of the present memoir and no attempt can be made to discuss it. The different opinions which have been maintained are, however, briefly the following: Daubenton and Cuvier were

¹ 'Trans. Roy. Irish Acad.,' xxxiii, B., pt. 1, p. 203.

disposed to derive the domestic dogs from the wolf; Nehring, partly from the wolf and partly from the jackal; Gueldenstädt, and G. St. Hilaire, from the jackal; de Blainville, Pictet, Boule (1889), Gaudry and Boule (1892), Bourguignat and Woldrich, from one or more extinct types of dog, neither wolves nor jackals; Studer, partly from wolves, partly from extinct types of dog; finally, von Pelzeln has recourse to all the above-mentioned sources—wolves, jackals and extinct types of dogs, and in addition derives certain races from the existing wild dogs, *Canis sinensis* and *Canis pallipes*. Jeitteles also has recourse to several living species, including the jackal and *Canis pallipes*.

V. CONCLUSIONS.

These may be very briefly stated and contain no element of novelty. In Pliocene times the wolf (*Canis lupus*) and common fox (*Canis vulpes*) were already inhabitants of Britain. In Pleistocene times they abounded and the Arctic fox (*Canis lagopus*) was sparingly represented; but no animals which can be distinguished as dogs have been recognised in Britain in Pleistocene deposits. In Pre-historic times, however, true dogs abounded. Doubt is expressed with regard to the desirability of recognising the occurrence of the genus *Lycaon* in England.

My sincere thanks are tendered to Mr. W. J. Lewis Abbott and Dr. F. Corner for kindly placing their large collections of canine bones from the Ightham fissure at my disposal for examination and figuring. I am much indebted to Mr. H. Bolton, Prof. T. McK. Hughes, Mr. A. Somervail and Dr. A. Smith Woodward for the loan of specimens preserved respectively in the Bristol, Sedgwick, Torquay and British Museums. I further wish to thank Dr. A. Smith Woodward, Dr. C. W. Andrews, Mr. R. Lydekker and Dr. R. F. Scharff for help and information, and Mr. J. Green for the care he has taken with the illustrations.

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PLATE I.

PLEISTOCENE CANIDÆ.

Cranium.

Wolf (*Canis lupus*).

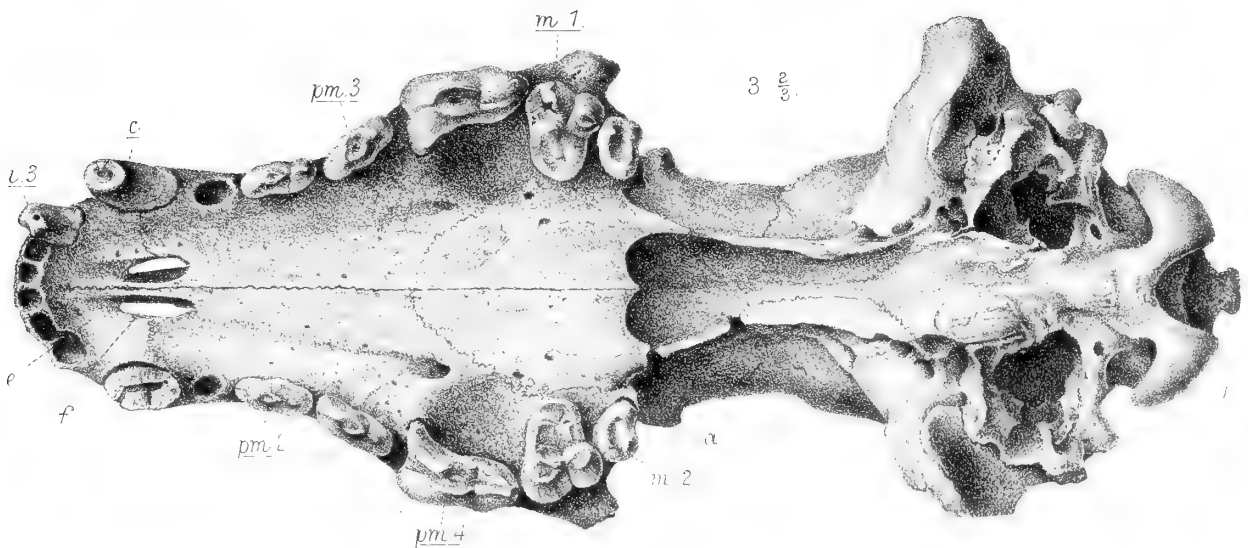
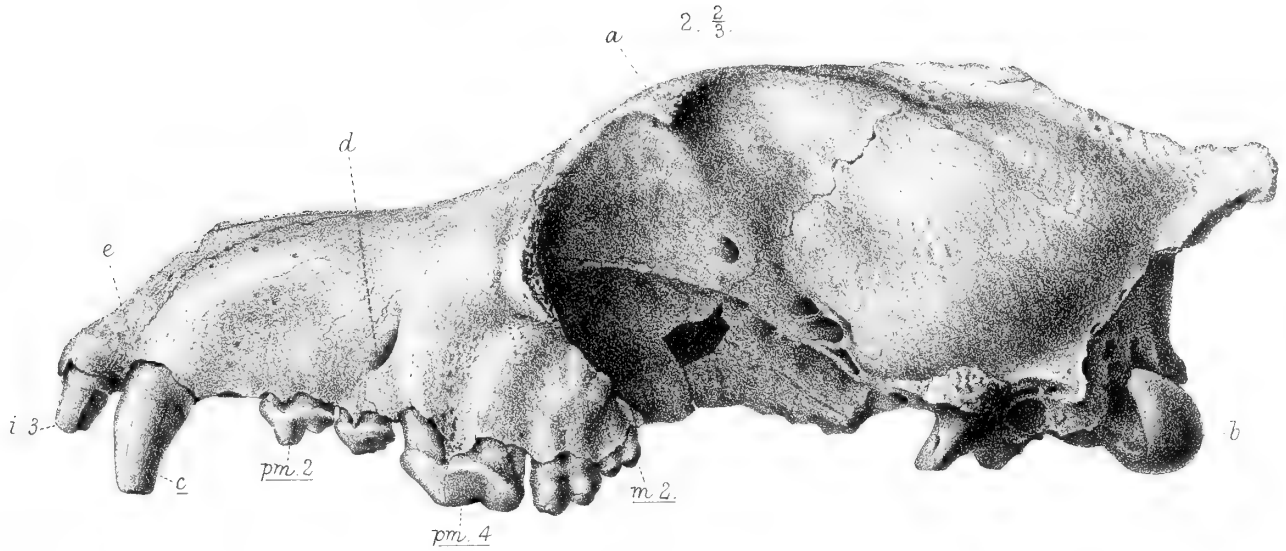
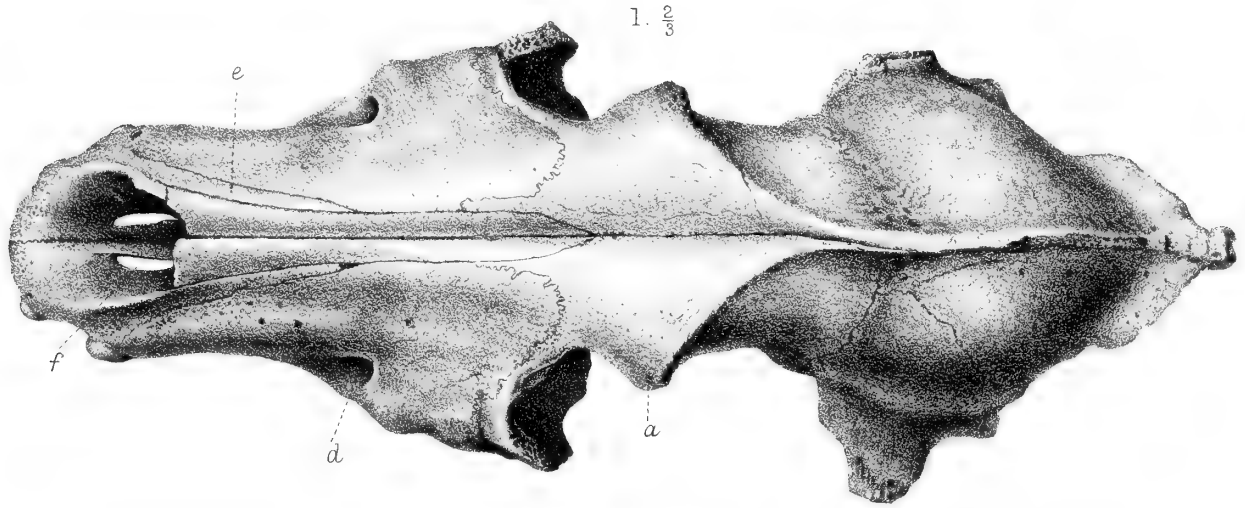
(Two thirds natural size.)

FIG.

- | | | |
|------------|---|--|
| 1. Dorsal | } | view of a cranium from Kent's Cavern, Torquay. |
| 2. Lateral | | |
| 3. Ventral | | |

This specimen, which was figured by MacEnery ('Cavern Researches,' Frontispiece) and by Owen ('British Fossil Mammals and Birds,' p. 123), is preserved in the Torquay Museum. Since these authors figured the skull, the mandible has been lost and the cranium has been somewhat damaged.

- a.* Post-orbital process of frontal.
- b.* Occipital condyle.
- c.* Canine tooth.
- d.* Infra-orbital foramen.
- e.* Premaxilla.
- f.* Anterior palatine foramen.



WOLF, CANIS LUPUS.
Cranium

PLATE II.

PLEISTOCENE CANIDÆ.

Cranium and Mandible.

Wolf (*Canis lupus*).

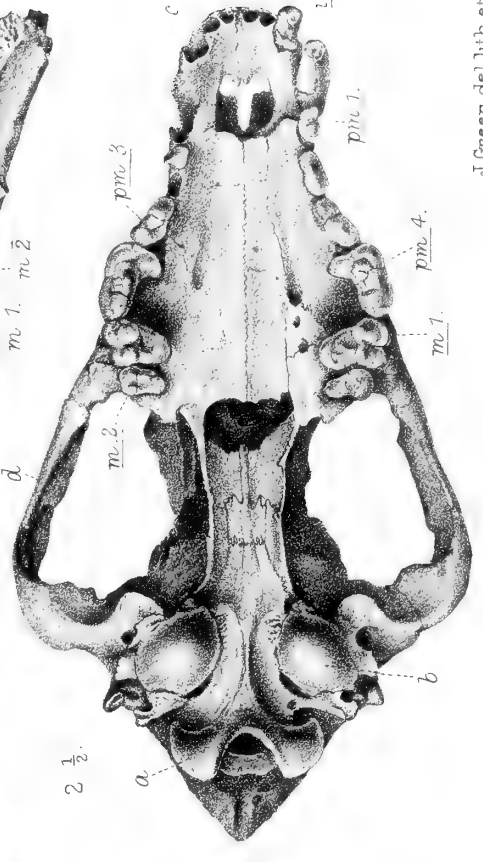
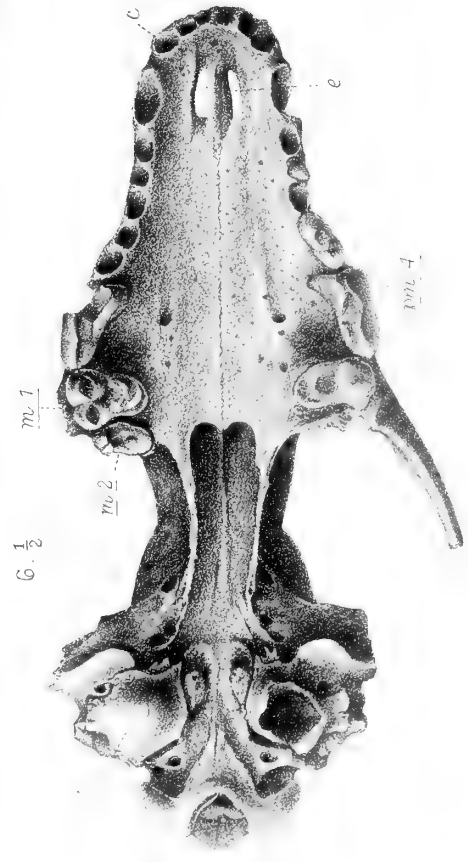
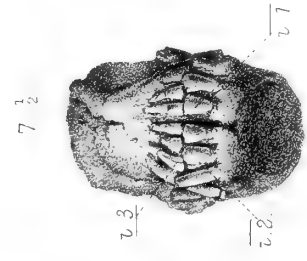
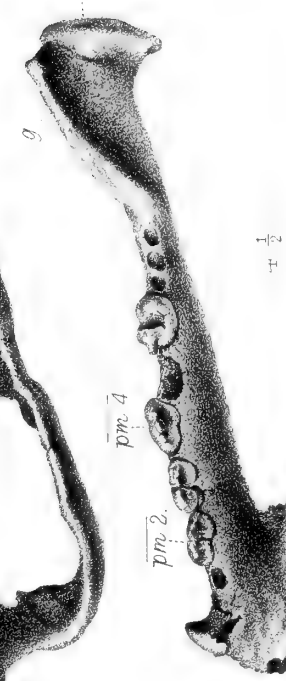
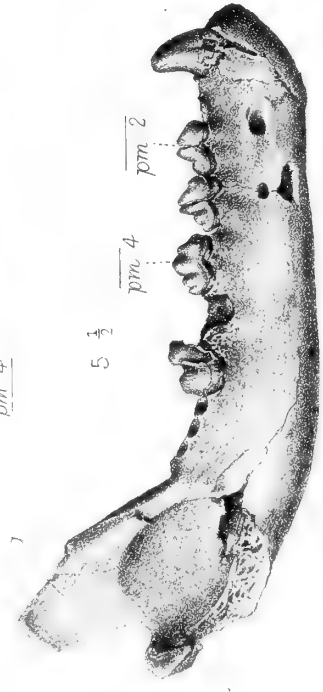
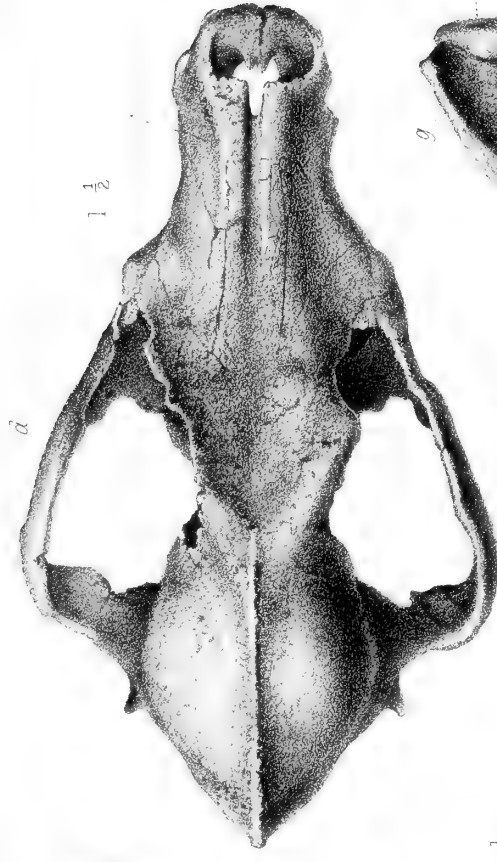
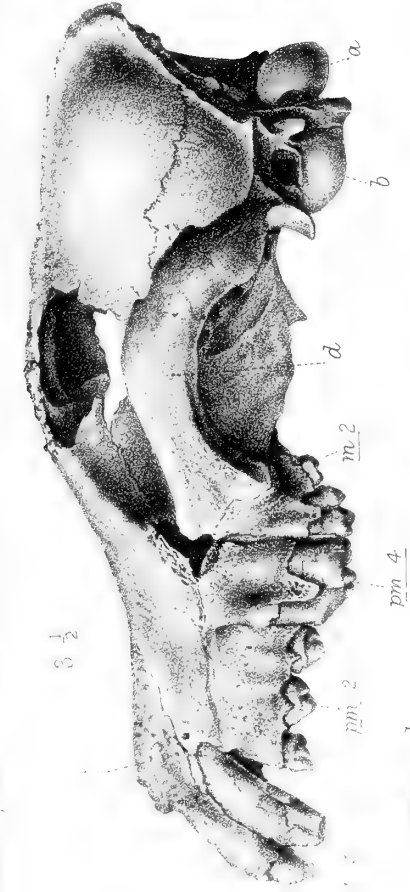
(One half natural size.)

FIG.

- | | | |
|---|---|---|
| 1. Dorsal | } | view of a cranium from Hutton Cave, Somerset. |
| 2. Ventral | | |
| 3. Lateral | | |
| 4. Palatal | } | view of the corresponding mandible. |
| 5. Lateral | | |
| 6. Ventral view of a cranium from Banwell Cave, Somerset. | | |
| 7. Anterior view of the jaws from Oreston Cave, Plymouth. | | |

All the above are preserved in the British Museum.

- | | |
|-----------|----------------------------|
| <i>a.</i> | Occipital condyle. |
| <i>b.</i> | Auditory bulla. |
| <i>c.</i> | Premaxilla. |
| <i>d.</i> | Jugal. |
| <i>e.</i> | Anterior palatine foramen. |
| <i>f.</i> | Mandibular condyle. |
| <i>g.</i> | Coronoid process. |



WOLF, CANIS LUPUS.
Cranium & mandible.

PLATE III.

PLEISTOCENE CANIDÆ.

Cranium and Mandible.

Common Fox (*Canis vulpes*).

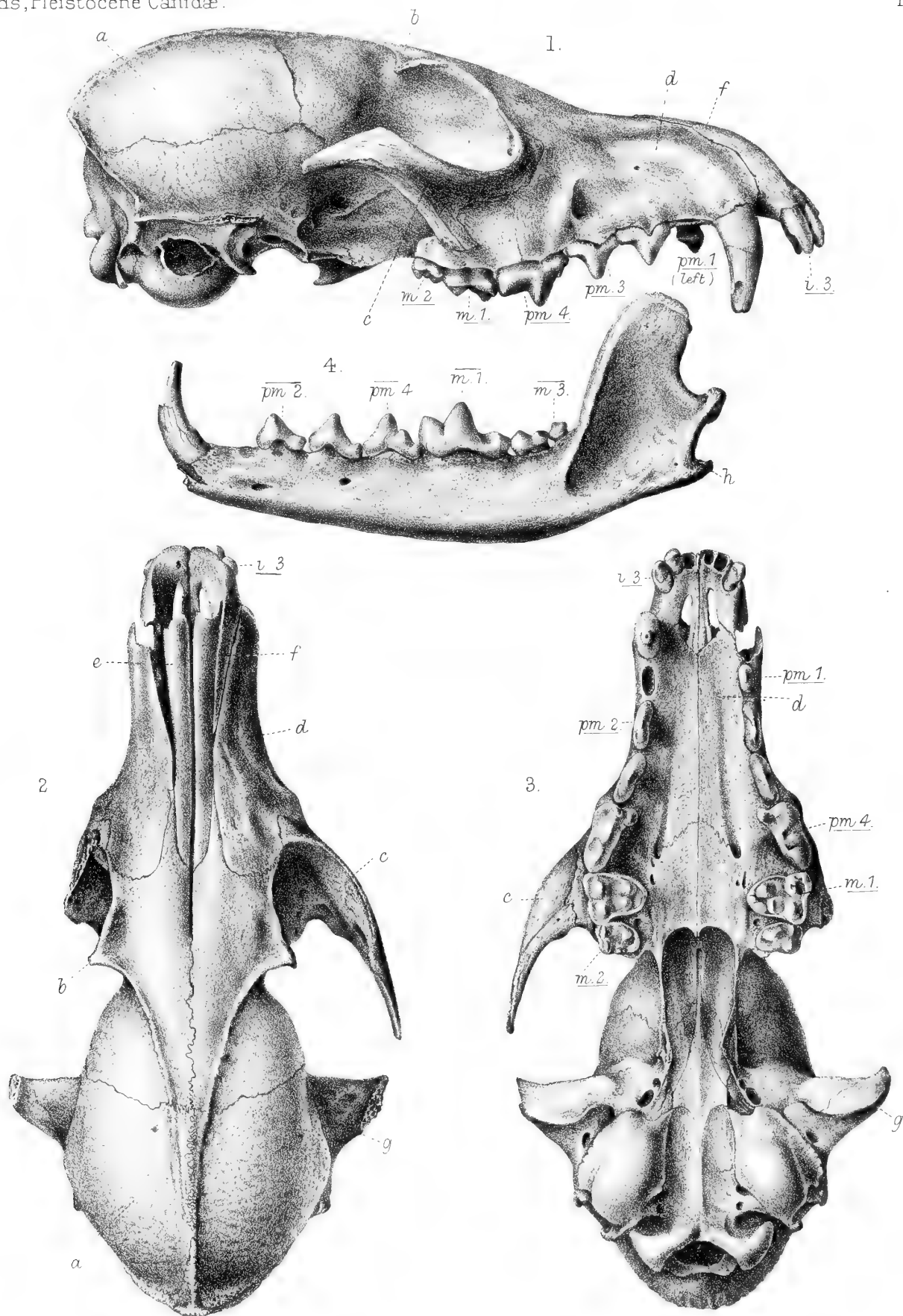
(Natural size.)

FIG.

1. Lateral
 2. Dorsal
 3. Ventral
 4. Left mandibular ramus seen from the outer side.
- } view of cranium.

These specimens are from the Pleistocene of the Ightham fissure, near Maidstone, and are preserved in the collection of Mr. W. J. Lewis Abbott, F.G.S., of St. Leonard's-on-Sea.

- a.* Parietal.
- b.* Post-orbital process of frontal.
- c.* Jugal.
- d.* Maxilla.
- e.* Nasal.
- f.* Nasal process of premaxilla.
- g.* Zygomatic process of squamosal.
- h.* Angle of mandible.



COMMON FOX, *CANIS VULPES*.
Cranium & mandible.

PLATE IV.

PLEISTOCENE CANIDÆ.

Cranium and Mandible.

Arctic Fox (*Canis lagopus*).

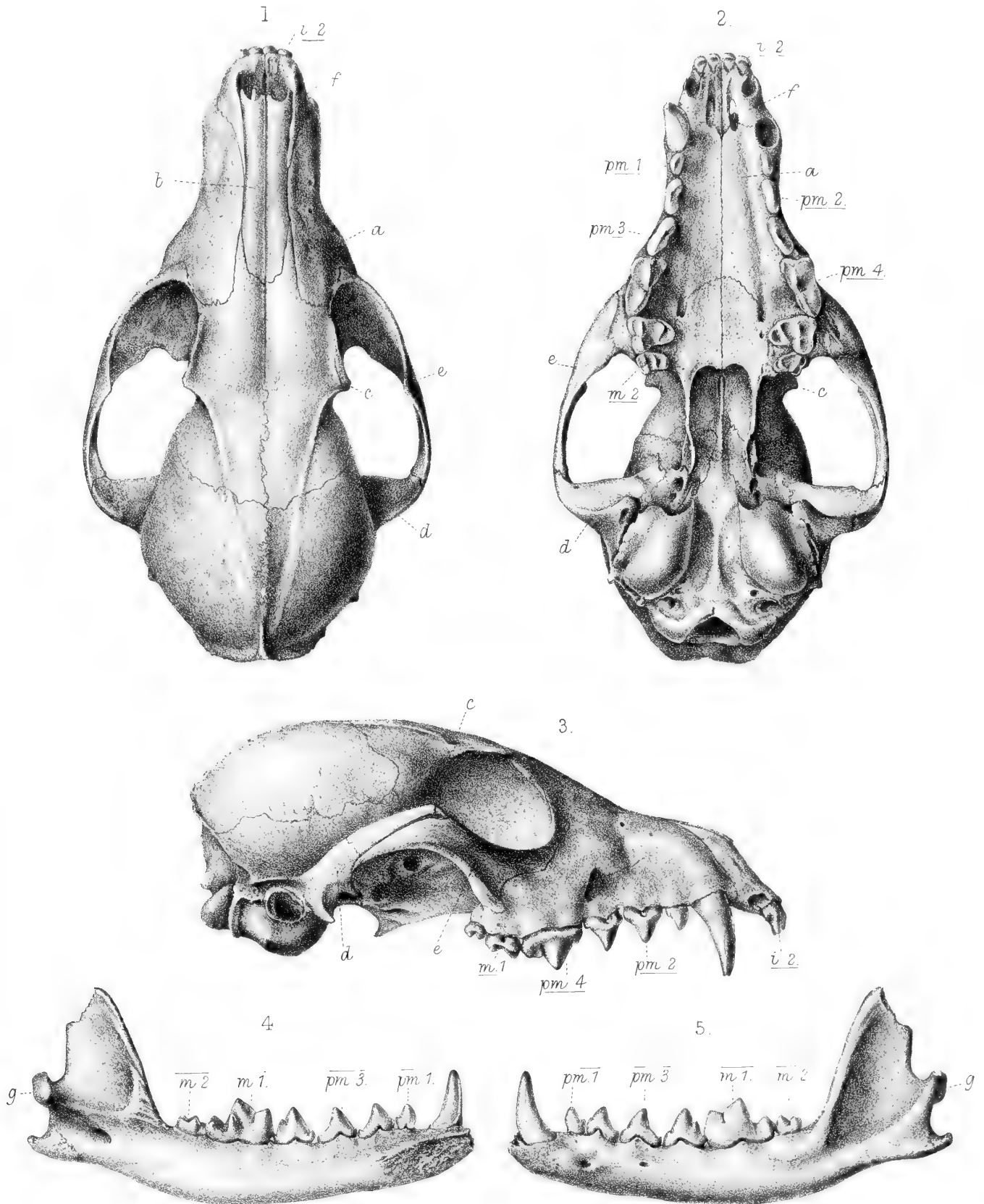
(Natural size.)

FIG.

- | | | |
|--|---|------------------|
| 1. Dorsal | } | view of cranium. |
| 2. Ventral | | |
| 3. Lateral | | |
| 4. Left mandibular ramus seen from the inner side. | | |
| 5. The same seen from the outer side. | | |

These specimens are from the Pleistocene of the Ightham fissure, near Maidstone, and are preserved in the collection of Mr. W. J. Lewis Abbott, F.G.S., of St. Leonard's-on-Sea.

- | | |
|-----------|----------------------------------|
| <i>a.</i> | Maxilla. |
| <i>b.</i> | Nasal. |
| <i>c.</i> | Post-orbital process of frontal. |
| <i>d.</i> | Zygomatic process of squamosal. |
| <i>e.</i> | Jugal. |
| <i>f.</i> | Premaxilla. |
| <i>g.</i> | Condyle of mandible. |



ARCTIC FOX, *CANIS LAGOPUS*.
Cranium & mandible.

PLATE V.

PLEISTOCENE CANIDÆ.

Dentition.

(Natural size.)

FIG.

1. Right upper permanent dentition of *Canis lupus*.
2. Right lower permanent dentition of *Canis lupus*.
3. Right upper deciduous dentition of *Canis* sp.
4. Right lower deciduous dentition of *Canis* sp.

The above teeth, which are all from the Pleistocene of the Torbryan Cave, Torquay, are in each case seen from the inner side. $\overline{\text{D.i.3.}}$ and $\overline{\text{d.c.}}$ were not represented in the series figured and are shown merely in outline. Preserved in the British Museum.

5. Right }
6. Left } mandibular ramus of a young Arctic Fox (*Canis lagopus*).

These specimens, both seen from the outer side, are from the Pleistocene of the Ightham fissure, near Maidstone, and are preserved in the collection of Mr. W. J. Lewis Abbott, F.G.S., of St. Leonard's-on-Sea.

7. and 8. Fourth lower premolar of the specimen from Sprintsail Tor, Gower, described as *Lyncaon anglicus*. This specimen is preserved in the British Museum.

7. Outer aspect. 8. Inner aspect.

a. Anterior cusp.

In all the above specimens the roots when shown in outline are not visible, being hidden by the bone of the jaw.



PLATE VI.

PLEISTOCENE CANIDÆ.

Vertebræ.

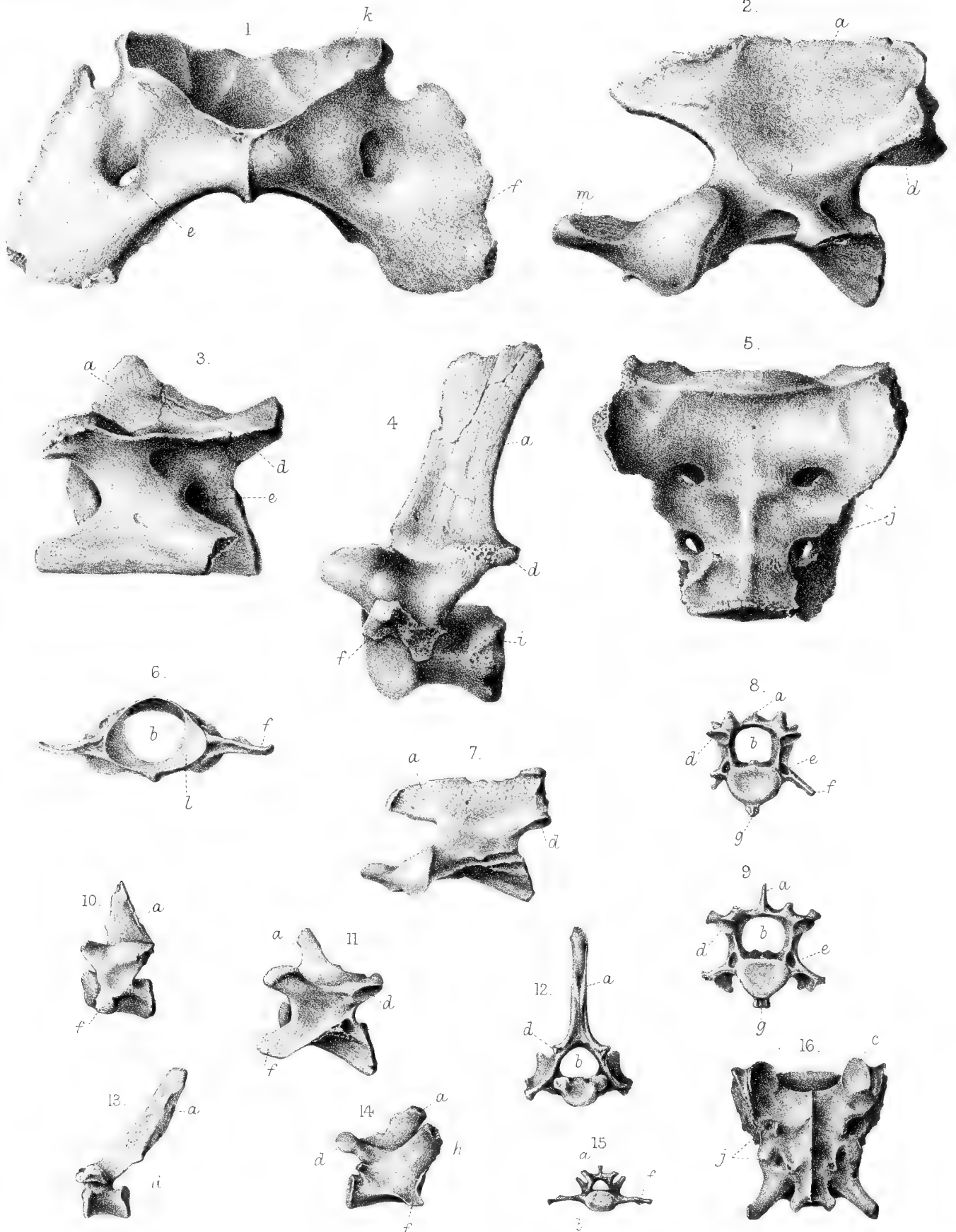
(Natural size.)

FIG.

1. Atlas, Wolf (*Canis lupus*), Oreston, ventral view.
 2. { 2, Axis; 3, fifth cervical; and 4, first thoracic; Wolf (*Canis lupus*), Durdham
 3. { Down, all seen from the left side.
 4. }
 5. Sacrum, Wolf (*Canis lupus*), Oreston, ventral view.
All the above are preserved in the Bristol Museum.
 6. Atlas, posterior view
 7. Axis, seen from left side
 8. Third cervical, posterior view
 9. Fourth cervical, posterior view
 10. Fifth cervical, seen from left side
- } Common Fox (*Canis vulpes*).
- The above are from the Pleistocene of the Ightham fissure, near Maidstone, and are preserved in the collection of Dr. F. Corner, F.G.S., of Poplar.
11. Seventh cervical, seen from left side
 12. First thoracic, posterior view
 13. Seventh thoracic, seen from left side
 14. First lumbar, seen from right side
 15. First free caudal, posterior view
- } Arctic Fox (*Canis lagopus*).

- The above are also from the Ightham fissure, and are preserved in the collection of Mr. W. J. Lewis Abbott, F.G.S.
16. Sacrum, Common Fox (*Canis vulpes*), Durdham Down, dorsal view, Bristol Museum.

- a.* Neural spine.
- b.* Neural canal.
- c.* Pre-zygapophysis.
- d.* Post-zygapophysis.
- e.* Vertebrarterial canal.
- f.* Transverse process.
- g.* Hypapophysis.
- h.* Metapophysis.
- i.* Surface for articulation with head of rib.
- j.* Nerve foramina.
- k.* Surface for articulation with condyle of cranium.
- l.* Posterior articular surface.
- m.* Odontoid process of axis.



Palæontographical Society, 1909.

THE
GANOID FISHES

OF THE
BRITISH CARBONIFEROUS FORMATIONS.

BY
RAMSAY H. TRAQUAIR, M.D., LL.D., F.R.S.,

LATE KEEPER OF THE NATURAL HISTORY COLLECTIONS IN THE ROYAL SCOTTISH
MUSEUM, EDINBURGH.

PART I, No. 4.

PALÆONISCIDÆ.

PAGES 107—122; PLATES XXIV—XXX.

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Fauna of Bohemia, published in 1893,¹ changed into *Trissolepis*, making the genus likewise into the type of a new family, "Trissolepidæ," of which I may quote his definition :

"Körper Palæoniscusartig, Schuppen hinter dem Kopfe bezahnt, am Körper cycloid, am Schwanze rhombisch. Hautknochen des Kopfes glatt mit wenig Leisten und Grübchen versehen. Vorderrand der Flossen ohne Fulcra. Gaumen stark bezahnt. Kiemenbögen mit starken Rechenzähnen, Mittellinie des Rückens bloss vor der Rückenflosse mit V-förmigen Schuppen, die allmählig in die Flossenstrahlen übergehen."

These characters are not, in my opinion, sufficient to warrant the separation of *Trissolepis* from the Palæoniscidæ, of which family I would consider it as an aberrant genus, resembling *Cryphiolepis* in having rounded scales, but differing in the more regularly cycloid form of these appendages in the want of fulcra on the fins and in the absence of the peculiar striated sculpture of scales and head-plates.

Again, with regard to the round-scaled *Coccolepis Bucklandi* of the Solenhofen Limestone, classed by Agassiz as one of the "Lepidoidei Heterocerci," I remarked in 1877 that "its relationship to the Palæoniscidæ seems to be indicated both by Agassiz's figure and description," and this surmise has been amply confirmed by Vetter² as regards the above-named species, and by Smith Woodward in his descriptions of *Coccolepis liassica* from the English Lias,³ and of *C. australis* from the Talbragar beds (Jurassic?) of New South Wales.⁴

It is also interesting that in these round-scaled Palæoniscidæ the scales of the caudal body-prolongation always preserve their original angular form, and that these scales persist also in their original form in the nearly naked Carboniferous *Phanerosteon*, the Liassic *Chondrosteus*, and the recent *Polyodon*.

Geological Position and Locality.—*Cryphiolepis striatus* is, with one exception, only known as occurring in the Borough Lee Ironstone, Middle Carboniferous Limestone or "Edge Coal" Series, worked at Borough Lee and Loanhead, near Edinburgh,—the exception being a single scale in the collection of the Geological Survey of Scotland in shale, also of "Edge Coal" age, from the "Burnlip Diamond Bore," two miles north of Coatbridge, near Glasgow. The original types are in the collection of the author.

¹ 'Fauna der Gaskohle und der Kalksteine der Perm-formation Böhmens,' Band iii, Heft 2, Prag, 1893, p. 76.

² "Die Fische aus dem lithographischen Schiefer im Dresdner Museum," 'Mittheil. k. Min.-geol. Mus. Dresden,' pt. iv, 1881, p. 37.

³ 'Ann. and Mag. Nat. Hist.' [6], vol. v, 1890, p. 435.

⁴ "Fossil Fishes of the Talbragar Beds," 'Mem. Geol. Survey N. South Wales,' Palæontology, No. 9, 1893, pp. 4—8.

Genus—ACROLEPIS, Agassiz, 1833.

? GYROLEPIS, Agassiz (pars).

PALÆONISCUS, G. A. Kurtze (pars).

PALÆONISCUS, E. F. Germar (pars).

HOLOPTYCHIUS, M'Coy (pars).

AMBLYPTERUS, A. Fritsch (pars), afterwards corrected.

? ELONICHTHYS, A. S. Woodward (pars).

ELONICHTHYS, Traquair (pars).

Generic Characters.—Fusiform or elongated; suspensorium oblique, gape wide; teeth sharply conical, of two principal sizes, a set of larger ones situated internally to a more numerous and closely placed set of smaller ones. Head-plates ornamented with ridges or tubercles which may pass into each other. Scales thick, with extensive covered area (Pl. XXV, figs. 2—4, 9—11) which is frequently produced upwards into a pointed process; articular peg and socket strongly developed in the flank-scales. Ornament of exposed area of scales normally consisting of prominent ridges passing obliquely across the surface, but which may coalesce at places so as to produce a reticulated or even pitted appearance. Posterior edges of scales in most species entire and undenticulated. Principal rays of pectoral fin unarticulated for about one third of their length; base of ventral not extended; dorsal placed nearly opposite the interval between the ventrals and the anal; dorsal and anal triangular-acuminate in shape; caudal powerfully heterocercal and deeply cleft. Fin fulcrum distinct but small.

Observations.—On the whole *Acrolepis* resembles *Elonichthys* pretty closely, though it is also very decidedly separated by the deeply imbricating arrangement of the scales with concomitant greater breadth of the overlapped area. As remarked above, the posterior margins of the scales are in most cases not denticulated; an exception seems, however, to occur in an African species from the Karoo formation named by Smith Woodward *Acrolepis* (?) *digitata*, in which “the hinder border exhibits a series of very large downwardly directed denticulations,”—it must, however, be remembered that he himself states that the name is a provisional one.¹ I have recently seen reason to transfer my *Acrolepis* (?) *Africana* from Nyassaland, in which the posterior margin of the scales is also denticulated, to the genus *Colobodus* of Agassiz. Nevertheless the presence of denticulations on the posterior borders of the scales seems after all to be only of specific value. For although this character, for example, is found pretty constantly throughout the genus *Rhadinichthys*, yet in at least two species referable thereto—*Rh. Macconochii*, Traq. and *Rh. tuberculatus*, Traq., to be presently described, the posterior margin in all the scales is quite plain.

In Pl. XXV, fig. 1, we have an outline sketch of the maxilla and mandible of the

¹ ‘Cat. Foss. Fishes Brit. Mus.,’ pt. ii, 1891, p. 508.

type species *Acrolepis Sedgwicki* from the Marl Slate, in which the Palæoniscid contour is well shown. Fig. 2 represents the outer and fig. 3 the inner surface of a flank-scale of the same species magnified, showing the great breadth of the covered area and the extensive production upwards of the antero-superior angle, while fig. 4 is a similarly shaped but smaller scale. Fig. 5 shows the transverse jointing of portions of two dorsal fin-rays with the sculpture of the exposed surfaces of the joints.

Species.—The undoubted species of *Acrolepis* are Carboniferous and Permian, the best known species *A. Sedgwicki*, Agass., and *A. exsculpta* (Kurtze) being from the Marl Slate and Kupferschiefer (Upper Permian) of England and Germany, while the largest known is *A. gigas*, A. Fritsch, from the Lower Permian of Bohemia. Doubtful species are *A. reticulata*, Eichw., from the Old Red Sandstone of Orel, Russia; *Acrolepis* (?) *Drummondi*, Traq., and *Acrolepis* (?) *digitata*, Smith Woodward, from the Karoo formation of Africa. The British Carboniferous species to be here described are *A. Hopkinsi*, M'Coy, *A. semigranulosa*, Traq., *A. ortholepis*, Traq., and *A. Wilsoni*, Traq.¹

1. ACROLEPIS HOPKINSI, M'Coy, sp. Plates XXIII, XXIV, and XXV, fig. 6.

? GYROLEPIS RANKINEI, Agassiz. Poiss. Foss., vol. ii, pt. i, 1844, p. 303 (name only).

HOLOPTYCHIUS HOPKINSI, M'Coy. Ann. Mag. Nat. Hist. [2], vol. ii, 1844, p. 2.

ACROLEPIS HOPKINSI, M'Coy. Brit. Palæoz. Foss., 1855, p. 609, pl. iii—G, fig. 10.

— Traquair. Quart. Journ. Geol. Soc., vol. xxxii, 1877, p. 571.

— RANKINEI, Traquair. Ibid., p. 571.

— HOPKINSI, Traquair. Proc. Roy. Soc. Edinb., vol. xvii, 1890, p. 398; and Cat. Carb. Fishes of West of Scotland in Brit. Assoc. Handbook, Glasgow Meeting, 1901, p. 515.

— A. S. Woodward. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 506.

Specific Characters.—A large species, having the external head-bones mostly ridged, the ridges passing sometimes into tubercles; scales having the exposed surface covered by well-marked sharp ridges, oblique and sub-parallel in direction, frequently intercalated, less often branching, save on the caudal region, where they are sometimes reticulated.

Description.—The original specimen from the Carboniferous Limestone of Derbyshire, described and figured by M'Coy, consists of two somewhat fragmentary scales, the

¹ A fish from the Carboniferous of Carlisle, Lanarkshire, is mentioned by Agassiz ('Poiss. Foss.', vol. ii, pt. ii, 1844, p. 162) under the name of *Acrolepis acutirostris*. No description was given, and nothing is known of the specimen.

reference of which to the genus *Acrolepis* is sufficiently obvious, and I am also unable to see any specific difference between them and those appertaining to other remains of the genus from Yorkshire, Lanarkshire, etc.

A series of thirteen fragments apparently belonging to one fish, from the Millstone Grit of Hebden Bridge, Yorkshire, and in the Davis Collection, British Museum, represents to my mind a species identifiable with that of M'Coy's scales from Derbyshire. One of these fragments, which shows an extensive portion of the squamation of the right flank, is represented in Pl. XXIV of the natural size. It must have belonged to an individual of between two and three feet in length, yet the scales do not seem proportionally very large. The exposed portion of the scales on the middle of the flank is about $\frac{1}{4}$ in. in breadth, and perhaps a little more in height, and is covered with well-marked ridges, sub-parallel, closely placed, occasionally branching and intercalated, their main direction being obliquely downwards and backwards across the surface of the scale, the posterior border of which is not denticulated. On an average fifteen of these ridges may be counted in the height of one of these flank-scales.

Another fragment shows some remains of the head, of which the most interesting is the parietal part of the cranial roof. This is ornamented with closely set, wavy, undulating rounded striæ, mostly longitudinal in their direction, and often looped, branching and interrupted, and at some places passing into tubercles. A similar ornament apparently characterised also the opercular bones, though it is not extensively seen. A portion of the clavicle is also seen, with strong striæ running in a transverse direction. On the mandible the striæ are longitudinal in their direction, but they are also extensively broken up into long-shaped tubercles. The maxilla is also seen, its post-orbital expansion being very strong, but as the outer surface is not seen its sculpture cannot be described.

Pl. XXIII represents an *Acrolepis* from the "Low Main" Coal Shale at Newsham, Northumberland, and contained in the Atthey Collection in the Newcastle Museum, which I have no hesitation in referring to the same species as the above. As it lies the specimen measures $13\frac{1}{2}$ inches in length, but being obliquely cut off just behind the ventral fin, its original length can scarcely have been less than 2 feet. The scales are much jumbled and confused, but agree in sculpture with those already described. The head is very well preserved; the antero-superior border of the left orbit is shown as well as the nasal opening of that side. The cranial roof-bones are, like those of the Hebden Bridge specimen, mainly striated, the ridges tending in places, especially on the snout, to pass into tubercles. The mandible is also longitudinally striated, and the broad post-orbital part seems also to have possessed a similar ornament, though its infra-orbital process is tuberculated. The pectoral fin is pretty well shown, though its distal extremity is somewhat frayed. From the figure it will clearly be seen that the principal rays are unarticulated for at least the first third of their length, and that the anterior margin is furnished with closely set prominent fulcra. The ventral fin is situated 6

inches behind the origin of the pectoral, but is badly preserved, little more being seen of it than the stumps of its truncated rays.

In Pl. XXV, fig. 6, is exhibited a specimen showing portions of three bands of flank-scales from the "Drumgray" Coal Shale, Carlisle, Lanarkshire. It belongs to the Rankin Collection, Hunterian Museum, University of Glasgow, and is therefore very probably one of the original types of *Gyrolepis Rankinei* of Agassiz. These scales show the typical *Acrolepis*-shape—the extensive covered area, prolonged upwards in a pointed process, and the deeply imbricating arrangement. The sculpture of the exposed area consists, as before, of closely set, sub-parallel ridges, passing obliquely downwards and backwards across the surface, frequently intercalated, sometimes branching, and ending on the non-denticulated hinder margin. That the fish to which these scales belonged was of large dimensions is evident, the height of the exposed area being no less than $\frac{5}{8}$ inch, the breadth a little less, but I see no reason why it should not be referred to *Acrolepis Hopkinsi*.

In 1877 I described a slab, from shale below the "Main" Limestone of Braidwood, Lanarkshire, in the collection of the late Dr. Hunter-Selkirk, and showed a number of scales and bones of a large *Acrolepis*, which I referred to *Acrolepis (Gyrolepis) Rankini*, Agassiz, sp. These remains seemed to show a character of their own, inasmuch as the head-bones presented more of a tubercular ornament than in the specimens above described, but I nevertheless cannot think it safe to found a new species on that character. The ridges on the scales of the caudal region form a reticulated pattern by coalescence.

Remarks.—The Lanarkshire specimens share with *Elonichthys pectinatus* the tradition of representing the *Gyrolepis Rankinei* of Agassiz, and of the two it is much more probable that the *Acrolepis* is the fish in question.¹ In fact, as I have already remarked, the specimen of scales from Dr. Rankin's collection, represented in Pl. XXV, fig. 6, may be indeed the type specimen. Agassiz's name is, however, merely a manuscript one and has therefore no authority, even if we had certainty on the subject, which we have not. And as I cannot find any positive mark of distinction between these Scottish specimens and those from Yorkshire and Northumberland, I must adopt M'Coy's name *Hopkinsi* for all.

Geological Position and Localities.—*Acrolepis Hopkinsi* occurs both in estuarine shales and in beds of obviously marine origin; it is also one of the few species of "Ganoids," which are found both above and below the Millstone Grit. It occurs in:

Lower Limestone Series: Braidwood, Lanarkshire. Cement Limestone Shale, East Kilbride.

Millstone Grit: Hebden Bridge, Yorkshire.

Lower Coal Measures: Kilmarnock Water; Newsham, Northumberland.

¹ "Leeds," however, is the locality given by Agassiz, 'Poiss. Foss.'; but "Lanarkshire" is added by Morris, 'Cat. Brit. Foss.,' p. 328.

The type is from the Carboniferous Limestone of Derbyshire and is contained in the Woodwardian Museum, Cambridge.

2. *ACROLEPIS SEMIGRANULOSA*, *Traquair*. Plate XXV, figs. 9—11.

ACROLEPIS SEMIGRANULOSUS, *Traquair*. Proc. Roy. Soc. Edinb., vol. xvii, 1890,
p. 398.

— *SEMIGRANULOSA*, *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., pt.
ii, 1891, p. 507.

Specific Characters.—Exposed surface of scales covered with innumerable closely set fine ridges, wavy and often tortuous, and tending at places to break up into minute tubercles.

Description.—The only specimen which has occurred hitherto is a patch of confused scales ten inches in length by four in greatest breadth, and including at one extremity a fragment apparently of one of the plates of the head. These scales are mostly flank-scales and are all more or less broken, the most entire one being the ventral scale represented in fig. 11. The covered area of the flank-scales (figs. 9 and 10) is extensive and passes upwards into a prominent pointed process; the exposed area has its antero-superior angle concavely truncated; the whole of this free surface is covered with fine, closely set ridges or striæ, wavy and often tortuous, bifurcating and interrupted, and tending in places to break up into minute tubercles, the main direction of these striæ passing in some cases (figs. 10 and 11) transversely or obliquely across the scale from back to front or in other cases (fig. 9) mainly vertically from above downwards. The scale represented in fig. 11, evidently a ventral scale, has its covered area produced obliquely upwards and forwards in a long, slightly curved pointed process, the length of which is more than twice the height of the free area of the scale. I can see no trace of denticulations along the posterior border of any of the scales shown in the specimen.

On the fragment of a large cephalic plate included in the specimen, the ornament consists entirely of minute and closely placed tubercles or granulations.

Observations.—That the scales described above belonged to a fish of the genus *Acrolepis* is, I think, perfectly evident from their shape, and their specific distinction is equally clear from their peculiar ornament, consisting as it does partly of very fine striæ and partly of minute tubercles.

Geological Position and Locality.—Lower Carboniferous. The above described unique specimen is in the Royal Scottish Museum, Edinburgh, and occurred in the "Dunnet" Shale, formerly worked at Straiton near Burdiehouse, Midlothian.

3. ACROLEPIS ORTHOLEPIS, *Traquair*. Plate XXV, figs. 7, 8.

ELONICHTHYS ORTHOLEPIS, *Traquair*. Geol. Mag. [3], vol. i, 1884, p. 10.

ACROLEPIS ORTHOLEPIS, *Traquair*. Proc. Roy. Soc. Edinb., vol. xvii, 1870,
p. 328; and Ann. Mag. Nat. Hist. [6],
vol. vi, 1890, p. 492.

— — A. S. Woodward. Cat. Foss. Fishes Brit. Mus., pt. ii,
1891, p. 508.

Specific Characters.—Scales not serrated posteriorly; those of the flank higher than broad; tolerably coarse ridges and furrows run parallel with the superior, posterior, and inferior margins and meet at acute angles on a strong diagonal elevation which runs downwards and backwards over the scale to the postero-inferior angle.

Description.—The type specimen, belonging to the British Museum Collection, is represented in Pl. XXV, fig. 7. The length of this example is exactly twelve inches, but the tip of the snout is not present. It is also slightly contorted or bent so that the back is more convex or gibbous than would otherwise be the case, while the ventral margin assumes a concave contour. Compression has also taken place in a somewhat oblique direction so that, the fish lying on its right side, the origin of the dorsal fin is slightly concealed by the scales of the left.

The general contour of the fish is fusiform, with a powerful heterocercal tail. If we allow $\frac{1}{2}$ inch for the missing part of the snout, the length of the head would be contained $5\frac{1}{2}$ times in the total.

The head has the usual Palæoniscid structure, but is so crushed and otherwise badly preserved that little more can be said of it. Traces of fine striæ are seen on the maxilla as well as on the mandible and on the opercular bones. The supra-clavicular element of the shoulder girdle shows the same kind of ridged sculpture so general in species of this and allied genera.

The scales are of moderate size and are not serrated along their posterior margins. Those of the flank (fig. 8) are higher than broad; as stated above, the ornament of their exposed surfaces consists of tolerably coarse ridges and furrows which run parallel with the superior, posterior, and inferior margins and meet at acute angles a strong diagonal ridge or elevation which runs obliquely downwards and backwards over the scale to the postero-inferior angle. In the scales further back this diagonal ridge becomes less marked and finally disappears, and towards the tail pedicle the sculpture becomes reduced to interrupted furrows and punctures, arranged diagonally in the middle of the scale, but at the periphery tending to be parallel with the superior, posterior, and inferior margins. On the small narrow scales of the caudal body-prolongation these markings appear mostly as simple diagonal furrows.

One of the pectoral fins is seen and attains a length of $1\frac{1}{3}$ inches, but it is not in a good state of preservation, its rays being rather broken up terminally and post-axially. I

should say that the principal rays must have been unarticulated for some extent of their length.

The ventral is also not in very good condition; as the specimen lies, it is placed nearer the anal than the pectoral. It appears small, but the broken up condition of its rays indicates that its size and form are not accurately preserved.

The dorsal commences slightly in front of a point midway between the posterior border of the gill cover and the commencement of the caudal fin. Its shape is triangular acuminate, its height in front attains $1\frac{1}{2}$ inches—though it must have been higher, as the base of the fin is partly concealed owing to the oblique compression of the specimen. The rays of the dorsal are rather distantly articulated, and each joint is ornamented on its exposed surface by one prominent smooth ridge or longitudinal elevation. Traces of oblique slender fulcra are seen along the anterior margin.

The anal fin agrees closely with the dorsal in configuration and structure; the length of its longest rays is $1\frac{3}{4}$ inches.

The caudal fin is large, inequilobate, and deeply bifurcate; the length of the upper lobe, measured from a point in the middle of the tail pedicle opposite the commencement of the lower one, being $3\frac{3}{4}$ inches. The longest rays of the lower lobe attain a length of $2\frac{2}{5}$ inches as preserved, but as the distal extremity of this part of the fin is not shown, the original length of these rays may be estimated at $2\frac{3}{4}$ inches. These rays of the lower lobe are more closely articulated than those of the other median fins, yet though the joints become shorter towards the extremities of the rays they never are so short as to appear square. The joints also show occasional longitudinal furrows on their ganoid surfaces, and the anterior margin of the fin is bordered by minute and oblique slender fulcra. The upper lobe possesses a very strong body-prolongation; its fringe-like rays are fine and begin to dichotomise about the middle of their length; the joints are rather longer than broad and apparently smooth externally.

Another specimen belonging to the Royal Scottish Museum has attained a size twice as great as that of the above-described original example, as it measures $25\frac{1}{2}$ inches in length. It is really nearly entire, the extremities of the caudal lobes only being deficient. As the general form of body and fins is well shown, it may be of interest to give the measurements of the specimen.

Entire length from the tip of the snout to the broken off					
extremities of the caudal lobes . . . . .	.	.	.	.	2 feet $1\frac{1}{2}$ inches.
Estimated length when entire . . . . .	.	.	.	.	2 feet 2 „
Length of head . . . . .	.	.	.	.	$4\frac{1}{2}$ „
Greatest depth of body between shoulder and ventral fin .	.	.	.	.	$5\frac{3}{4}$ „
From tip of snout to opposite commencement of ventral fin .	.	.	.	.	$11\frac{3}{4}$ „
„ „ „ „ dorsal .	.	.	.	.	13 „
„ „ „ „ anal .	.	.	.	.	$16\frac{1}{4}$ „
„ „ „ „ lower lobe of	.	.	.	.
caudal .	.	.	.	.	$20\frac{3}{4}$ „

The scales, although not jumbled, are nevertheless not well shown, being much broken in the splitting of the large nodule in which the fish is contained, but it is clear that they were thick, not denticulated posteriorly, and with a broad overlapped anterior area. Wherever the sculpture of the exposed surface is visible, it agrees essentially with that on the scales of the first described specimen, so that there is no doubt as to specific identity. The pectoral fin measures 4 inches in length; the ventral, which is not long-based, measures $2\frac{1}{2}$ inches at its anterior border, and, as in the previous specimen, its position lies nearer to the anal than to the pectoral. The dorsal, triangular-acuminate with concave posterior border, has a base of 3 inches in length, which is also the length of its longest rays in front. Concerning the anal and the caudal nothing special need be said.

There is also, in my private collection, a juvenile specimen which measures $3\frac{1}{2}$ inches in length, without the head and the extremity of the upper lobe of the caudal fin, which are deficient. Though the scales in this specimen are naturally very small and the markings few, yet their style is quite recognisable. Noteworthy points are the proportionally distant character of the transverse articulations of the fin-rays, and the difficulty in making out the presence of fulcra on the anterior margins, which points are, in my opinion, connected with the youth of the individual. The ventral fin is here also nearer in position to the anal than to the pectoral.

Observations.—I originally referred this species to *Elonichthys*, adopting the specific name *ortholepis* on account of the want of denticulations along the posterior borders of the flank-scales, which fact alone, I confess, ought to have made me think of the genus *Acrolepis*. The scale characters of *Acrolepis* are, however, so evident in the subsequently discovered larger specimen, that I had no hesitation in transferring the species to that genus, these characters being the great thickness of the scales and the breadth of their anterior covered area.

Geological Position and Locality.—As yet found only in the fish-beds of Lower Carboniferous age exposed in the banks of the River Esk at Glencartholm, Dumfriesshire.

4. ACROLEPIS WILSONI, *Traquair*. Plate XXV, figs. 12, 13.

ACROLEPIS WILSONI, *Traquair*. Geol. Mag. [3], vol. v, 1888, p. 254.

— — A. S. Woodward. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891,
p. 507, pl. xv, fig. 3.

Description.—Only scales are as yet known, which indicate a fish of considerable size. The exposed surface is rhombic, closely covered with small pits about $\frac{1}{14}$ inch in diameter, which in the middle of the area are arranged somewhat irregularly, but above and below are disposed in three or four regular lines parallel with the upper and lower

margins respectively. The surface between the pits is minutely fretted with excessively delicate grooves which are only perceptible by aid of a lens. The well-developed covered area projects upwards in an angular process; the articular spine is well developed.

Observations.—The original specimen was recognised as new by the late Mr. J. Ward of Longton, who passed it on to me for description with the request that I would name it after its finder, Mr. E. Wilson, F.G.S. Since that time it has come into the possession of the British Museum, as have likewise the specimens here figured. The shape of these scales indicates *Acrolepis* as the genus, and the peculiarity of their markings is such as to entitle the fish to which they belonged to most unmistakable specific distinction.

Geological Position and Locality.—From the Yoredale Series of Turnditch near Belper, Derbyshire.

Genus—NEMATOPTYCHIUS, *Traquair*, 1875.

1844. PYGOPTERUS, *Agassiz* (pars).

1875. NEMATOPTYCHIUS, *Traquair*.

Generic Characters.—General form elongated; suspensorium very oblique; gape wide; teeth sharply conical, enamel-capped, of different sizes, large and small, the large ones forming a row internal to the more numerous and closely placed small ones. Flank-scales much higher than broad, with a flat triangular articular process arising from the whole or nearly the whole of the upper margin; antero-superior and postero-inferior angles of the exposed surface of the scale obtuse; covered area of scale extremely narrow; ornament of exposed surface consisting of fine, closely set thread-like ridges; paired fins moderate in size; principal rays of pectoral unarticulated for some slight distance from their origin; ventral fin situated rather nearer to the anal than to the pectoral, its base not elongated. Dorsal fin situated far back, nearly opposite the anal; both are triangular-acuminate; caudal powerful, deeply bifurcated. Marginal fulcra on all the fins very distinct but small.

The form of the scales, with the backward position of the dorsal fin, is characteristic for the genus, of which only one species is as yet known.

NEMATOPTYCHIUS GREENOCKI, *Traquair*. Plate I, figs. 7—11; Plate XXVI.

- | | | |
|------------------------|-------------------------------|--|
| PYGOPTERUS GREENOCKII, | <i>Agassiz</i> . | Poiss. Foss., vol. ii, pt. ii, 1844, p. 78 |
| | | (undefined). |
| — | — | <i>Traquair</i> . Proc. Roy. Soc. Edinb., vol. v, 1866, p. 597. |
| — | — | <i>Traquair</i> . Trans. Roy. Soc. Edinb., vol. xxiv, 1867, p. 701, pl. xlv. |
| — | ELEGANS, <i>C. W. Peach</i> . | Rep. Brit. Assoc., 1871 (1872), Trans. Sect., p. 109 (name only). |

- NEMATOPTYCHIUS GREENOCKII, *Traquair*. Ann. Mag. Nat. Hist. [4], vol. xxv, 1875, p. 258, pl. xvi, figs. 7—11.
- GRACILIS, *Traquair*. Proc. Roy. Soc. Edinb., vol. ix, 1877, p. 262.
- GREENOCKII, *Traquair*. Quart. Journ. Geol. Soc., vol. xxxiii, 1877, p. 577.
- — *Traquair*. Ganoid Fishes Brit. Carb. Form. (Pal. Soc., 1877), p. 15, pl. i, figs. 7—11.
- — *Traquair*. Proc. Roy. Phys. Soc. Edinb., vol. v, 1879, pp. 118, 128.
- — *Traquair*. Proc. Roy. Soc. Edinb., vol. xvii, 1890, pp. 331, 398.
- GREENOCKI, *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 458.
- — *Traquair*. Trans. Roy. Soc. Edinb., vol. xlv, 1897, p. 111.

Description.—The two most nearly complete specimens which I have seen were found by myself many years ago at Wardie, one of these being represented in Pl. XXVI, fig. 1. Its length as it lies is $14\frac{1}{2}$ inches, but allowing for the deficiency of the extremities of the lobes of the caudal fin its original length was probably two inches more. The other one (not figured) is larger, being 16 inches in length as preserved, but in like manner its original length could not have been less than 18 inches.

The general shape of the body is elongated, the dorsal and ventral margins in front of the dorsal and anal fins being tolerably straight, and the dorsal fin rather far back so that we are reminded of the form of a recent pike. The length of the head is greater than the greatest depth of the body and is contained over four times in the calculated total.

The osteology of the cranial shield has already been described at p. 15 of this monograph and illustrated by figs. 7 and 8 of Pl. I. On Pl. XXVI, fig. 3, I give another figure showing the internal surface of another cranial shield from Straiton, near Burdiehouse, which is interesting in showing the course of the right and left sensory canals (*s.c.*) indicated in relief on the surfaces of the parietal and frontal elements.

The external facial bones are also represented in the restored figure of the head (Pl. I, fig. 11). It will there be seen that the suspensorium is very oblique, the operculum (*op.*) and suboperculum (*i. op.*) rather small: the preoperculum (*p. op.*), represented detached in fig. 4, is of the usual Palæoniscid form, but I have not noticed any of the accessory plates which are present in *Elonichthys*. The branchiostegal plates (*br.*) are very numerous, the anterior one of each series being specially broad in form, but I have not seen any evidence of the presence of a median plate as in *Elonichthys*, *Rhadinichthys*, etc. The maxilla (*mx.*), isolated in Pl. XXVI, fig. 5, is large and has its broad post-orbital part ornamented by striæ, which run parallel with the superior and posterior borders, but the oral margin of the whole bone, as shown

in fig. 5 of this Plate, is finely tuberculated. The mandible is composed of four pieces at least—the dentary, articular, angular, and splenial. The dentary is represented isolated in Pl. XXVI, fig. 6; it is elongated but strong, and is slightly bent upwards at its anterior extremity; its external surface is beautifully and closely tuberculated, the tubercles being sometimes longitudinally elongated into short ridges. The splenial element is shown, detached, in Pl. I, fig. 10; the position of the angular (*ag.*) and articular (*ar.*) in figs. 9 and 11 of the same Plate.

The palatoquadrate apparatus is elongated and concave externally, like that of other Palæoniscidæ. It certainly consists of several pieces—of three and probably also of a fourth—but my material is not yet sufficiently perfect to enable me to give a definite figure and description of the arrangement.

Teeth occur on the dentary element of the mandible and on the maxilla and premaxilla, but, so far as I can see, *not* on the splenial or on the hard palate. They are, as usual, of different sizes, the small ones being more externally placed than the large or “laniaries”; they are sharp, conical, enamel-capped, slightly incurved, smooth on the outer side, while the inner one is slightly striated; the pulp cavity is very roomy at the base (Pl. XXVI, fig. 7).

The scales, as noted in the generic diagnosis, are peculiar in form (figs. 9—11). All along the back and flanks they are much higher than broad; the exposed area is indeed more or less rhomboidal, but the acute angles are here the postero-superior and the antero-inferior. The antero-superior angle is not produced into a point, distinct from the proper articular peg, or spine, which latter, broad and triangular (fig. 9), arises from the entire upper margin of the scale. The exposed ganoid surface is ornamented by very delicate thread-like wavy ridges, branching and intercalated, which on the scales of the flank are subparallel and run more or less vertically down the scale, or between the two acute angles (fig. 9); on the scales of the back, however, they often follow a more irregular and flexuously contorted course (fig. 11). On the under or attached surface of the scale the usual keel is obsolete.

On the ventral surface of the body the scales are very small and so low as to appear equilateral; all the scales, however, appear to have the same ornamentation, consisting of fine wavy *thread-like* ridges, whence the generic name *Nematoptychius*.

The elements of the shoulder girdle are conformed as in other Palæoniscidæ, and do not call for special description.

The pectoral fin is not shown in the fine example represented in Pl. XXVI, fig. 1, but in fig. 8 we have a good view of it, all except the apex, which is cut off by the edge of the stone—another specimen, not figured, shows, however, that this fin was pointed distally. Fig. 8 shows well the condition of the principal rays as to transverse articulation, the first joint of each of these rays being much larger than those which succeed.

The ventral fin of the right side is shown in fig. 1, its extremity being cut off, like those of the other fins of this specimen, by the edge of the nodule. The base is rather

wide, measuring one inch across, and the number of its rays may be estimated at no less than thirty-five.

The dorsal fin is placed very far back, being nearly opposite the anal. Triangular-acuminate in form, it consists approximately of about forty-five rays, which are rather coarser in the anterior two thirds of the fin, but become finer posteriorly. The transverse articulations of the individual rays are rather close together, but the joints are still longer than broad, and the whole ray bifurcates a little beyond its middle.

The anal fin is the counterpart of the dorsal in form and structure, but appears to be very slightly larger. The form and position of these two fins are well seen in Pl. XXVI, fig. 2, which is from the "Dunnet" Shale of Straiton, and represents a smaller specimen.

The caudal fin, seen most completely in fig. 2, is large, deeply cleft, and strongly heterocercal.

All the fins are set with small, yet distinct fulcra along their anterior margins, and these are also best seen in fig. 2, which is taken from a shale specimen and not from one preserved in clay ironstone, like most of the others on the same Plate.

Remarks.—In his 'Poissons Fossiles,' vol. ii, p. 78, Agassiz referred to a species of "*Pygopterus*" as occurring in the Carboniferous Shales of Newhaven (Wardie), near Edinburgh, which he named *P. Greenocki*, in honour of Lord Greenock, the first collector of ichthyolites from that locality, and in whose collection the specimens were contained.

"*Pygopterus Greenocki*" belongs, however, to the category of "*nomina nuda*," as he did not accompany it by any valid description, saying merely that it was an "Espèce très-distincte sous le rapport spécifique mais douteuse sous le rapport générique. Les fragmens connus ne sont guère que des têtes avec la partie antérieure du tronc. Les écailles qui recouvrent cette partie du corps sont plus hautes que longues, et diffèrent par là de celles de tous les autres *Pygopterus*." Nevertheless, I think we may with tolerable, if not with absolute, certainty identify with this "*Pygopterus*" certain heads of a large Palæoniscid from Wardie, presented by Lord Greenock to the Royal Society of Edinburgh, and now in the teaching collection of the Geological Department of Edinburgh University.

Having had the good fortune to find at Wardie two entire specimens, I devoted my first palæichthyological paper to a description of these remains, in which I showed that the cranial osteology of this so-called "Sauroid" was on the same lines as in fishes referred by Agassiz to *Amblypterus*, one of his so-called "Lepidoids." In that paper I retained the generic name *Pygopterus* for the large Palæoniscid in question, as unfortunately I had not at that time enjoyed the opportunity of studying the characters of the typical *Pygopterus* of the Marl Slate and Kupferschiefer. However, some years later (1875) I showed that the species *Greenocki* could not possibly be classed in the genus *Pygopterus*, and established therefore the new genus *Nematoptychius* for its reception.

In 1877 I imagined that I had discovered a new species of *Nematoptychius* from the Gilmerton Ironstone, which I named *N. gracilis*. The specimen, in the Royal Scottish Museum, is a small fish nine inches in length and differing from the typical *Greenocki* principally in the more distant articulations of the fin-rays and in the more regularly tapering form of the teeth. Enlightened by experience I came, however, to look upon the first supposed diagnostic mark to be a sign of youth, and to put no weight on the second. Accordingly in 1890 I cancelled the species.

C. W. Peach's "*Pygopterus elegans*," founded on some dentigerous bones from Loanhead, now in the Royal Scottish Museum, is clearly a synonym of *Nematoptychius Greenocki*.

The predaceous habits of the larger Palæoniscidæ are well illustrated by a specimen of *Nematoptychius Greenocki* from the Borough Lee Ironstone in my own collection, in the abdominal cavity of which the remains of a good-sized *Acanthodes* are distinctly recognisable. This phenomenon is also frequently exhibited by large specimens of *Rhabdolepis macropterus*, a Lower Permian Palæoniscid common in the ironstone nodules of Saarbrücken and Lebach in Rhenish Prussia. In all these cases the *Acanthodes* was swallowed head foremost, as is shown by the position of its remains in the body of the larger fish. This must necessarily have been so, as in any other position its formidable spines would have proved an insuperable obstacle to its being swallowed at all.

Geological Position and Localities.—*Nematoptychius Greenocki* is one of the most common and widely distributed of all the estuarine fishes of the Lower Carboniferous rocks of the East of Scotland, occurring as it does in almost every fish-bearing bed of that category from the Wardie Shales to the Upper Limestone Series. Beginning with the lowest horizon in which its remains occur, we note its appearance first in the—

Calcareous Sandstone Series: Common in the ironstone nodules washed out of the shales at Wardie Beach. Burdiehouse Limestone, Burdiehouse, and Burntisland. Shales on the sea coast at Gullane, East Lothian. Roof of "Dunnet" Shale and "Broxburn" Shale at Straiton near Burdiehouse; also at Oakbank and West Calder. Pitcorthy near Anstruther, Fifeshire.

Lower Limestone Series: Gilmerton Ironstone at Venturefair Pit, Gilmerton.

Edge Coal Series: Loanhead Ironstone, No. 1, at Loanhead and West Edge. Borough Lee Ironstone, or Loanhead No. 2, at Borough Lee and Loanhead. Lower Possil Ironstone, Possil, Lanarkshire. Wallyford near Musselburgh.

Upper Limestone Series: Roof Shale of "South Parrot" Coal seam, at Niddrie near Edinburgh.

In 1875 I mentioned the occurrence of a maxilla of *N. Greenocki* in the Coal Measures of Shawfair near Dalkeith. I have seen reason, however, to believe that the specimen in question came from the Edge Coal Series at Wallyford, and that consequently there is as yet no record of the genus in Upper Carboniferous rocks.

Genus—CYCLOPTYCHIUS, *Young*, 1866.

Generic Characters.—Form narrow and elongated; suspensorium oblique and gape wide; dentition of the normal Palæoniscid type, the teeth being conical, sharp, and enamel-capped, and of two sizes, an inner set of larger teeth being present along with an outer series of smaller ones. Scales rhombic, their postero-inferior angles tending to be rounded off; sculpture consisting of ridges with a more or less concentric arrangement. Pectoral fin having its principal rays unarticulated till towards their terminations; ventral placed midway between the pectorals and the anal; dorsal fin situated nearly opposite the anal, both being triangular-acuminate; caudal heterocercal, deeply cleft and inequilateral; fulcra on all the fins distinct.

Cycloptychius resembles *Rhadinichthys* in many points, but is amply distinguished by the form and mode of sculpture of the scales and by the still more backward position of the dorsal fin. Only two species are known, one from the Upper, the other from the Lower Carboniferous rocks of Great Britain.

1. CYCLOPTYCHIUS CARBONARIUS, *Young*. Plate XXVII, figs. 1—5; Text-figure 5.

CYCLOPTYCHIUS CARBONARIUS, *J. Young* (ex Huxley MS.). Rep. Brit. Assoc. for 1865 (1866), p. 319.

CYCLOPTYCHIUS, *Hancock and Atthey*. Ann. Mag. Nat. Hist. [4], vol. i, 1868, p. 362.

— CARBONARIUS, *T. P. Barkas*. Coal Meas. Palæontology, 1873, p. 36, fig. 140.

— — *Traquair*. Geol. Mag. [2], vol. i, 1874, p. 241, pl. xii.

— — *Ward*. Proc. N. Staffs. Nat. Field Club, 1875, p. 240.

— *W. J. Barkas*. Monthly Rev. Dental Surgery, vol. iii, 1875, p. 500, figs. lxviii—lxx.

— CARBONARIUS, *Ward*. Trans. N. Staffs. Inst. Mining Engineers, vol. x, 1890, p. 179, pl. iv, figs. 3—5.

— — *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 460.

Specific Characters.—Scales rhombic, with rounded postero-inferior angle; ridges fine, thread-like; one of the ridges running along the upper part of the posterior margin is generally more or less zigzagged, so as to give almost a crenulated aspect to that margin.

Description.—The following description is taken from specimens from the “Deep mine” Ironstone shale of North Staffordshire collected by the late Mr. John Ward, and now in the British Museum. All the specimens but one are the remains of small fishes,

measuring from about $3\frac{1}{2}$ to $4\frac{1}{2}$ inches in length; the exception is formed by the head and fore part of the body of an individual which must have, when entire, measured at least 6 or 7 inches. The general form is elegant and slender; the greatest depth is at the shoulders, whence the body gradually tapers towards the caudal extremity. Taking into account the phenomena of "shortening up" and "lengthening out," so common among Palæozoic fossil fishes, the head would occupy about one fifth of the total length, while the ventrals would be situated at rather less than two fifths, and the beginning of the dorsal and anal fins at less than three fifths from the tip of the snout.

The osteology of the head is typically Palæoniscid, with oblique suspensorium, wide gape, and prominent superethmoidal prominence. The external surfaces of the bones of the cranial roof seem to have been finely tuberculated, the tubercles being sometimes confluent into short ridges. In one specimen a good view of the hyomandibular element

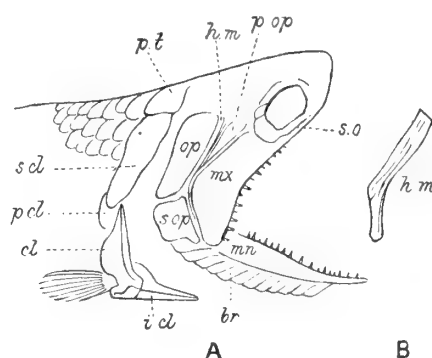


FIG. 5.—A. Sketch of the side of the head with the bones of the face and shoulder of *Cycloptychius carbonarius*, somewhat enlarged and restored. *Op.*, operculum; *p.op.*, preoperculum; *s.op.*, suboperculum; *s.o.*, suborbital; *mx.*, maxillary; *mn.*, mandible; *h.m.*, hyomandibular; *br.*, branchiostegal rays; *p.t.*, post-temporal; *s.cl.*, supra-clavicular; *cl.*, clavicle; *p.cl.*, post-clavicular; *i.cl.*, infra-clavicular. B. Isolated hyomandibular bone of *Cycloptychius carbonarius*. Magnified slightly.

is obtained. It is a somewhat long-shaped bone (Text-fig. 5 B), which descends obliquely downwards and backwards towards the articulation of the lower jaw, and is compressed laterally, while below the middle it is slightly bent forwards again at a low angle; *in situ* the upper part is very oblique, the lower nearly perpendicular. The orbit is, as usual, placed far forwards and surrounded by a chain of ossicles whose exact number can scarcely be determined. The maxillary bone is stout and broad till it comes to the orbit, where, as in other Palæoniscidæ, it is suddenly cut away, the anterior extremity passing on below the eye in a pointed process towards the premaxillary. The operculum is rather narrow, though broader above than below; the suboperculum is small and quadrate in shape; the branchiostegal rays or plates are numerous. The mandible, whose separate elements it is impossible to define, is stout in its posterior half, but tapers nearly to a point anteriorly.

The teeth, with which the margins of both jaws are armed, are of the usual type, being conical, sharp, slightly incurved, and enamel-capped. They are of two sizes—"large"

PLATE XXIV.

(The cost of this plate has been defrayed by the Carnegie Trust for the Universities of Scotland.)

Acrolepis Hopkinsi, McCoy. Portion of the squamation of the flank, from the Millstone Grit of Hebden Bridge, Yorkshire ; natural size. In the Davis Collection, British Museum (Natural History), no. P. 7672.

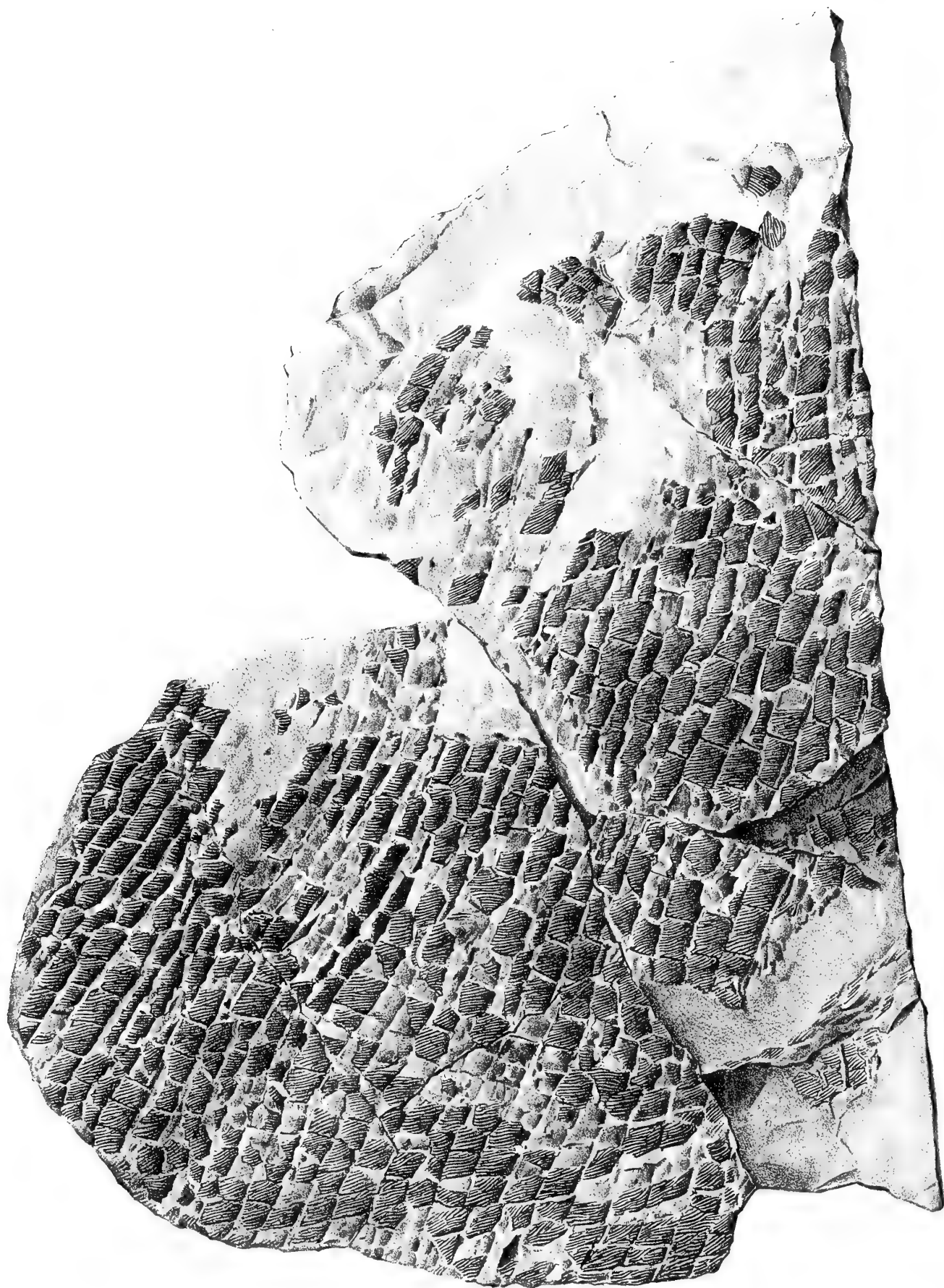


PLATE XXV.

(The cost of this plate has been defrayed by the Carnegie Trust for the Universities of Scotland.)

FIG.

1. Outline sketch of the maxillary bone and mandible of *Acrolepis Sedgwicki*, Agassiz; from a specimen from the Marl Slate of Midderidge in the Enniskillen Collection, British Museum (Natural History), no. P. 3407; natural size.
2. Flank-scale of the same species, outer surface, magnified. British Museum (Natural History).
3. Similar scale, inner surface, magnified. British Museum (Natural History).
4. Another detached scale of the same species, outer surface, from the same horizon and locality; magnified. British Museum (Natural History).
5. Portions of two dorsal fin-rays of *Acrolepis Sedgwicki*, Agassiz, magnified; showing the method of transverse jointing, with the exposed sculptured, and the overlapped smooth surfaces of the successive joints. From the same horizon and locality as the above. British Museum (Natural History).
6. *Acrolepis Hopkinsi*, McCoy. Portions of three bands of flank-scales; natural size. From the Drumgray Coal Shale, Carlisle, Lanarkshire. In the Rankine Collection, Hunterian Museum, University of Glasgow.
7. *Acrolepis ortholepis*, Traquair; natural size. From the Lower Carboniferous (Calcareous Sandstone Series) of Glencartholm, Eskdale, Dumfriesshire. The type specimen, in the British Museum (Natural History), no. P. 4081.
8. External surfaces, magnified seven diameters, of a group of four flank-scales of the same specimen.
9. *Acrolepis semigranulosus*, Traquair. Outer surface of flank-scale magnified by one half. From the type specimen from the Dunnet Shale (Calcareous Sandstone Series) of Straiton, Midlothian. In the Royal Scottish Museum, Edinburgh.
10. Another scale from the same specimen, similarly magnified, showing the striæ breaking up into granules on the upper part of the surface.
11. Another scale, probably from near the ventral margin, from the same specimen, similarly magnified.
12. *Acrolepis Wilsoni*, Traquair. Scales of type specimen, magnified two and a half diameters. From the Yoredale Series at Turnditch, near Belper, Derbyshire. British Museum (Natural History), no. P. 5329.
13. Another group of scales of the same specimen, magnified one and a half diameters.



Fig. 7.



Fig. 6

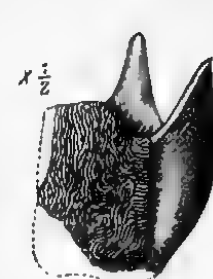


Fig. 9

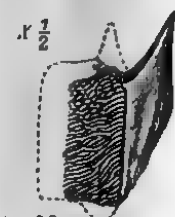


Fig. 10



Fig. 11.

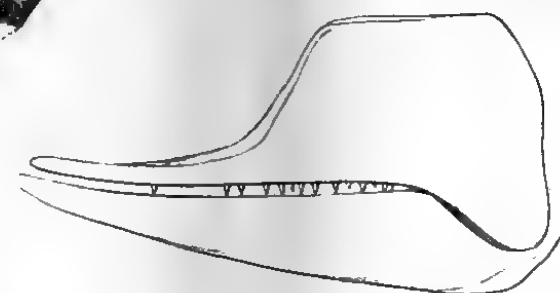


Fig. 1.



Fig. 13



Fig. 12.



Fig. 4.



Fig. 2.

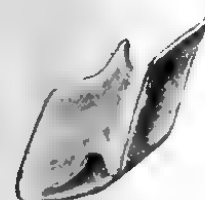


Fig. 3



Fig. 5



Fig. 8.

PLATE XXVI.

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FIG.

1. *Nematoptychius Greenocki*, Traquair; natural size. From the Lower Carboniferous (Calciferous Sandstone Series) at Wardie, near Edinburgh. One of the type specimens, in the Collection of the Author.
2. Caudal portion of another specimen, from the Dunnet Shale of Straiton, Midlothian; natural size. In the Royal Scottish Museum, Edinburgh.
3. A nearly entire cranial buckler of the same species seen from the internal surface; natural size; from the same horizon and locality as no. 2. *ff.*, frontals; *pa.*, parietals; *sq.*, squamosals; *e.*, superethmoidal; *s. c.*, sensory canal.
4. Detached preopercular plate of the same species; natural size. From the roof-shale of the "South Parrot" coal-seam, Niddrie, Midlothian (Upper Limestone Group). In the Royal Scottish Museum, Edinburgh.
5. Maxillary bone of the same species, from the same horizon and locality as no. 4. The posterior expanded portion is seen only in impression, but the bone is preserved along the dentary margin, where it displays numerous laniary teeth.
6. Dentary element of the mandible of the same species, seen from the outside and magnified by one half. The sculpture of the external surface and the dentition are well displayed. From the Calciferous Sandstone Series, Pitcorthy, Fifeshire. In the Royal Scottish Museum, Edinburgh.
7. Maxillary laniary tooth of the same species, seen from the inner surface and magnified six diameters. The enamel-cap of the apex is well shown, and, a piece of the base of the tooth having been splintered off, the wide pulp cavity of this portion of the tooth, filled with calcareous spar, is displayed. From Wardie.
8. A fragment, showing the proximal part of the left pectoral fin of the same species; natural size. From Wardie. In the Collection of the Author.
9. Flank-scale of the same species, showing the external sculptured surface and the articular process of the upper margin; magnified three diameters. From Wardie.
10. Inner surface of a similar scale, magnified three diameters. From Wardie.
11. External sculptured surfaces of a group of four dorsal scales, also magnified three diameters. From Wardie.



Fig. 1



Fig. 2

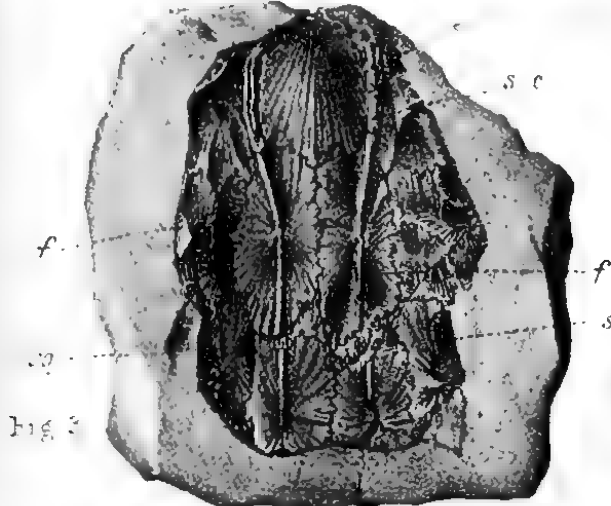


Fig. 3

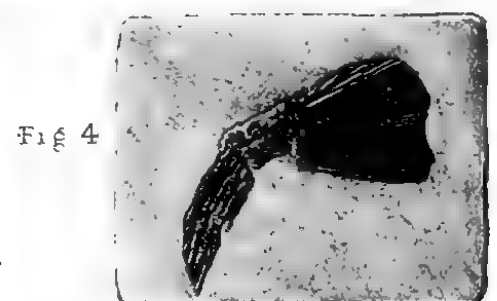


Fig. 4

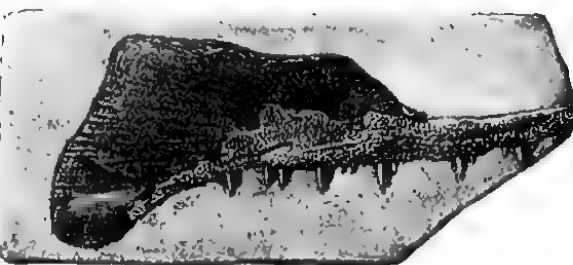


Fig. 5

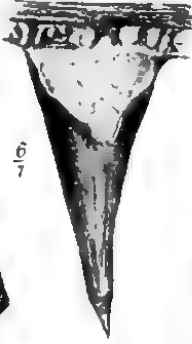


Fig. 6



Fig. 7



Fig. 8



Fig. 9



Fig. 10



Fig. 11

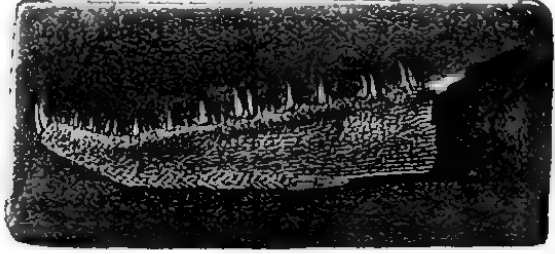


Fig. 12

PLATE XXVII.

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FIG.

1. *Cycloptychius carbonarius*, Young; natural size. The front part of the head is lost. From the Deep-mine Ironstone Shale, Longton, Staffordshire. In the Royal Scottish Museum, Edinburgh.
2. Another specimen showing the head well, but the caudal fin badly. In the Ward Collection, British Museum (Natural History), no. P. 7966; from the same stratum and locality.
3. Another specimen from the same stratum and locality, also in the Ward Collection, British Museum (Natural History), no. P. 7967. The head and anterior part of the body are wanting, but the caudal fin is exceedingly well shown.
4. Exposed surfaces of three flank-scales of the same species, magnified, showing sculpture.
5. Entire outline of another flank-scale magnified.
6. *Cycloptychius concentricus*, Traquair; natural size. From the Lower Carboniferous (Calcareous Sandstone Series) of Glencartholm, Eskdale, Dumfriesshire. In the Collection of the Author.
7. Sculptured surfaces of two flank-scales of the same species, magnified six diameters.
8. Sculptured surfaces of three scales above the lateral line, magnified six diameters.
9. Sculptured surfaces of two scales, situated near the caudal extremity, magnified six diameters.

Fig. 1.

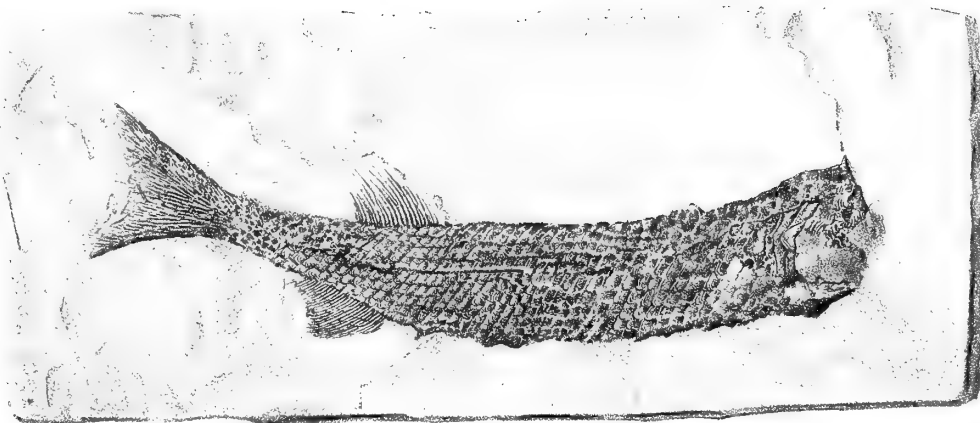
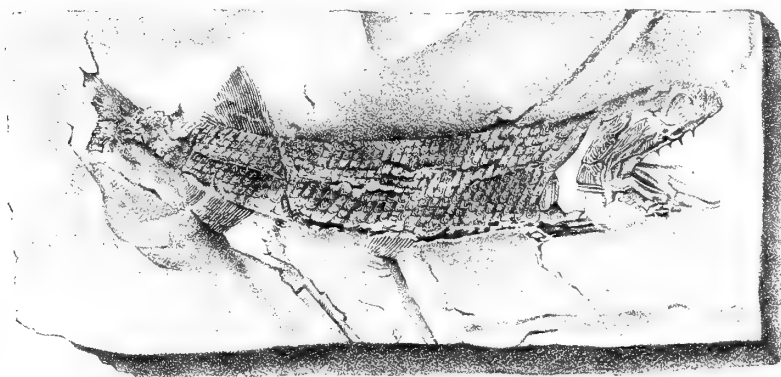


Fig. 2.



P. A. T.

Fig. 4.



Fig. 5.



Fig. 8.



Fig. 9.



Fig. 7.

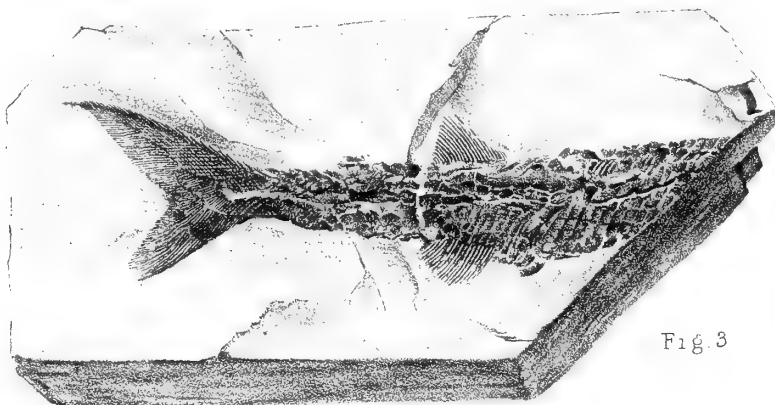


Fig. 3.

P. A. T.

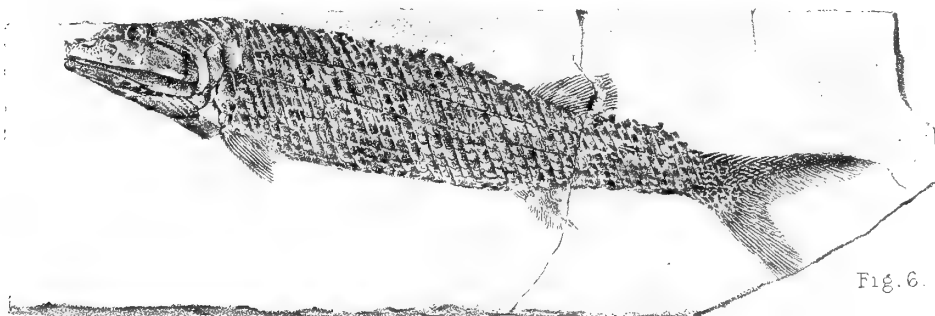


Fig. 6.

PLATE XXVIII.

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FIG.

1. *Rhadinichthys ornatissimus* (Agassiz) ; natural size. A remarkably perfect specimen from the Dunnet Shale (Calcareous Sandstone Series) of Straiton, Midlothian. In the Royal Scottish Museum, Edinburgh.
2. A large specimen of the same species from the Burdiehouse Limestone, Burdiehouse, showing the pectoral fin exceedingly well; natural size. Hugh Miller Collection, in the Royal Scottish Museum, Edinburgh.
3. Head of another specimen from the Calcareous Sandstone of Wardie, near Edinburgh, obliquely compressed; natural size. *op.*, operculum; *s. op.*, lower margin of suboperculum; *mx.*, part of maxilla; *mn.*, mandible; *br.*, branchiostegal plates; *br.*¹, anterior broad plate of right and left branchiostegal series; *br.*¹¹, median plate; *cl.*, portion of lower extremity of clavicle; *i. cl.*, infraclavicular plate.
4. Dentary element of mandible of the same species, showing the external sculpture, but not the teeth, which are concealed in the stone; magnified by one half. From the Dunnet Shale, Straiton. In the Royal Scottish Museum.
5. Flank-scale of the same species; magnified six diameters. From Straiton.
6. Scale further back; magnified six diameters. From Straiton.
7. Another posterior scale, magnified six diameters. From Straiton.
8. Proximal portions of three fin-rays of the same species at the anterior commencement of the dorsal fin, showing the form of the joints and the commencement of the fulcra; magnified six diameters.



Fig. 1.

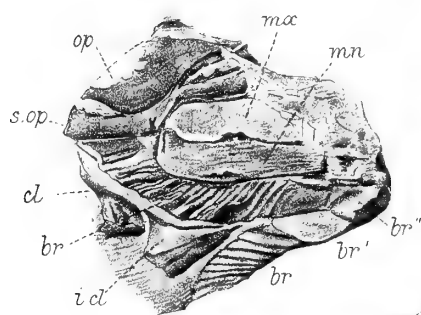


Fig. 3.



Fig. 8



Fig. 7



Fig. 6

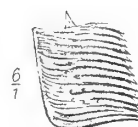


Fig. 5.



Fig. 4.



Fig. 2

PLATE XXIX.

(The cost of this plate has been defrayed by the Carnegie Trust for the Universities of Scotland.)

FIG.

1. *Rhadinichthys carinatus*, Agassiz ; natural size. From the Pumpherston Oil Shale (Calcareous Sandstone Series), Broxburn, West Lothian. In the Royal Scottish Museum, Edinburgh.
2. Another specimen from the same horizon and locality ; natural size. In the Royal Scottish Museum, Edinburgh.
3. Anterior part of another specimen, to show the pectoral fin ; natural size. From the same horizon at Pumpherston. In the Collection of the Author.
4. Scale from the nape of the neck ; magnified four diameters.
5. Flank-scale ; magnified six diameters.
6. Another flank-scale ; magnified six diameters.
7. *Rhadinichthys Macconochii*, Traquair ; natural size. From the Lower Carboniferous (Calcareous Sandstone Series), Glencartholm, Eskdale, Dumfriesshire. In the Royal Scottish Museum, Edinburgh.
8. Scales from the nape of the neck of the same species ; magnified six diameters.
9. Flank-scales ; magnified six diameters.
10. Scales further back ; magnified six diameters.
11. One of the narrow ventral scales ; magnified six diameters.

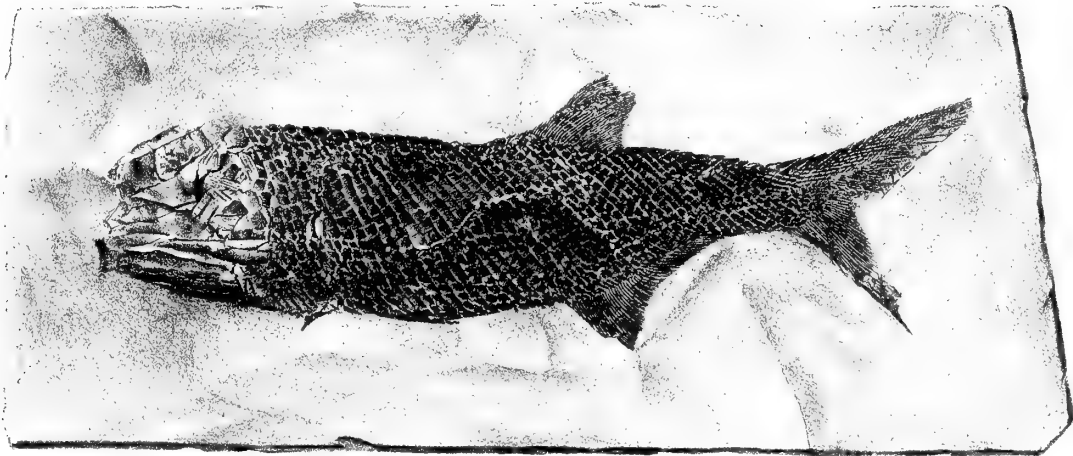


Fig. 1



Fig. 4.

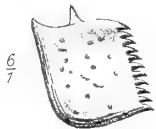


Fig. 5.



Fig. 6.

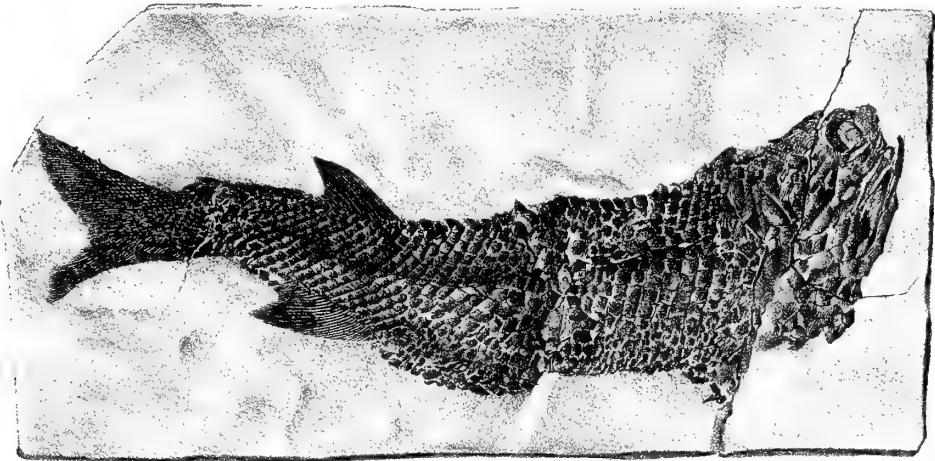


Fig. 2



Fig. 3.



Fig. 8

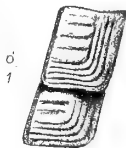


Fig. 9.



Fig. 10.



Fig. 11

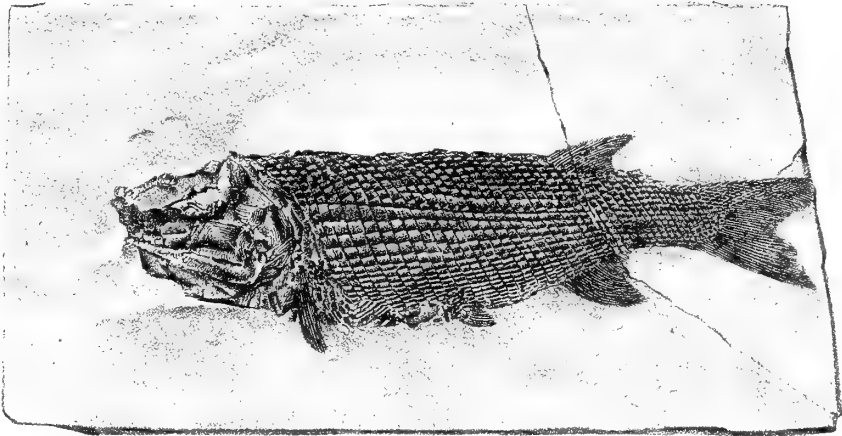


Fig. 7.

PLATE XXX.

(The cost of this Plate has been defrayed by the Carnegie Trust for the Universities of Scotland.)

FIG.

1. *Rhadinichthys Canobiensis*, Traquair; natural size. From the Lower Carboniferous (Calcareous Sandstone Series) of Glencartholm, Eskdale, Dumfriesshire. In the Royal Scottish Museum, Edinburgh.
2. Flank-scale of the same species; magnified six diameters.
3. The same, a less ornate variety; magnified six diameters.
4. Scales situated further back, towards the tail; magnified six diameters.
5. Narrow abdominal scales; magnified six diameters.
6. Scale from the nape of the neck; magnified six diameters.
7. *Rhadinichthys elegantulus*, Traquair; natural size. From Glencartholm. In the Collection of the Geological Survey of Scotland. This is the original of *Rh. Geikiei*, var. *elegantulus*, Traquair.
8. Head of the same specimen enlarged two and a half times. *p.*, parietal; *f.*, frontal; *e.*, superethmoidal; *or.*, orbit; *op.*, operculum; *s. op.*, suboperculum; *mx.*, maxilla; *d.*, dentary of mandible; *p.t.*, post-temporal; *s. cl.*, supra-clavicular; *cl.*, clavicle.
9. Scales from the nape of the neck of the same specimen; magnified six diameters.
10. Flank-scales; magnified six diameters.
11. Scale towards the tail; magnified six diameters.
12. *Rhadinichthys Canobiensis*, var. *delicatulus*, Traquair; natural size. From the same horizon and locality as the above. Also in the Collection of the Geological Survey of Scotland.
13. Sketch of the head of the same specimen enlarged two and a half times. Lettering as in Fig. 8.
14. Flank-scales of the same; magnified six diameters.
15. Scales further back; magnified six diameters.

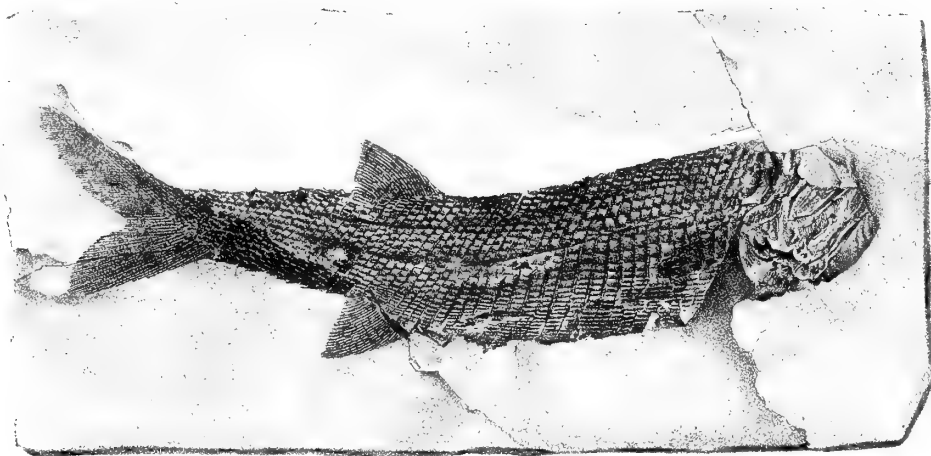


Fig. 1.



Fig. 2.



Fig. 3.



Fig. 4.



Fig. 5.



Fig. 6.



Fig. 9.

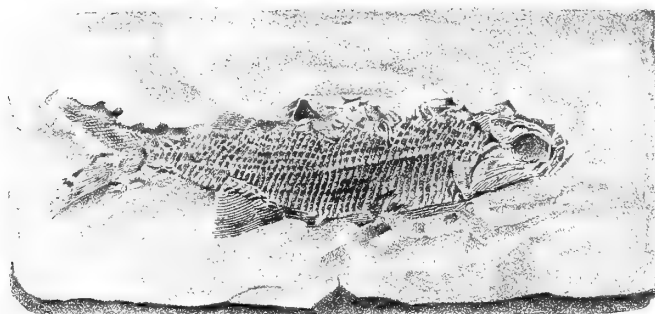


Fig. 7.

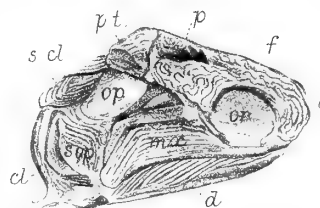


Fig. 8.



Fig. 10.



Fig. 11.



Fig. 14.

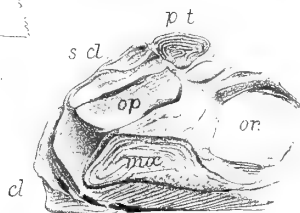


Fig. 13.



Fig. 15.

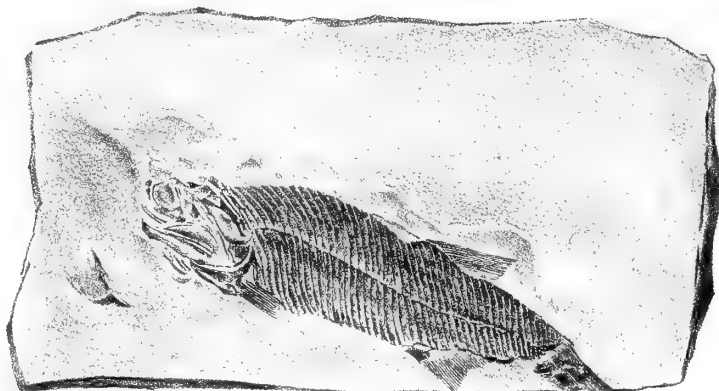


Fig. 12.

Palæontographical Society, 1909.

THE
FOSSIL FISHES
OF THE
ENGLISH CHALK.

BY

ARTHUR SMITH WOODWARD, LL.D., F.R.S.,

KEEPER OF THE DEPARTMENT OF GEOLOGY IN THE BRITISH MUSEUM; SECRETARY OF THE
PALÆONTOGRAPHICAL SOCIETY.

PART V.

PAGES 153—184; PLATES XXXIII—XXXVIII.

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1909.

ADLARD AND SON, IMPR., LONDON AND DORKING.

3. **Protosphyræna minor** (Agassiz). Plate XXXIII, figs. 1, 2.

1837-44. *Tetrapterus minor*, L. Agassiz, Poiss. Foss., vol. v, pt. i, pp. 7, 91, pl. lx a, figs. 9, 10 (*non* figs. 11-13).

1888. *Protosphyræna minor*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 321.

1890. *Protosphyræna minor*, J. Felix, Zeitschr. deutsch. geol. Ges., vol. xlii, p. 299.

1895. *Protosphyræna minor*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iii, p. 406.

Type.—Fragment of rostrum, probably from a Cenomanian zone; British Museum.

Specific Characters.—Rostrum comparatively delicate and much elongated, attaining a length of at least 15 cm.; the transverse section a depressed oval throughout its length, and the internal cavity extending a considerable distance towards the gradually tapering end; the external surface ornamented with coarse, closely-arranged, parallel longitudinal ridges, and its upper aspect marked with a median longitudinal groove, which does not obliterate the ornamentation.

Description of Specimens.—This species is known only by portions of rostrum. The type specimen lacks the distal end, but this is shown in the original of Pl. XXXIII, fig. 1. The proximal half, which is excavated by a relatively large central cavity, is always badly preserved. The longitudinal ridges of the conspicuous external ornament (fig. 2) sometimes anastomose and are sometimes intercalated, while on the ventral surface (fig. 2 a) they occasionally pass into a well-marked reticulation. Towards the blunt end of the rostrum the bone becomes nearly smooth.

As already remarked (p. 95), the terminal caudal vertebræ provisionally ascribed to this species by Agassiz, belong to a teleostean fish of the genus *Ichthyodectes*.

Horizon and Localities.—Zone of *Holaster subglobosus*: near Lewes, Sussex; Burham, Kent.

4. **Protosphyræna stebbingi**, sp. nov. Plate XXXIII, fig. 3.

Type.—Portions of rostrum from zone of *Holaster subglobosus*; collection of W. P. D. Stebbing, Esq.

Specific Characters.—Rostrum depressed into a flattened blade, probably attaining a length of from 35 to 40 cm., with a basal width of 4 to 5 cm.; upper surface rising to the middle line, where it is traversed by a longitudinal groove, which has a flattened, smooth floor and sharply-raised, tuberculated edges; ornament of this surface consisting of low, rounded, longitudinal ridges and rows of circular pittings; the lateral edges ornamented with stronger ridges, which are partly longitudinal, partly oblique; the terminal portion with the flattened upper surface only longitudinally ridged, the lateral edges and lower surface smooth.

Description of Specimen.—This species is known only by the two pieces of one rostrum shown in Pl. XXXIII, figs. 3, 3 *a*. The basal region is crushed and broken, displaying a very large central cavity, which becomes smaller forwards, and is then divided into two by the usual median partition; even in the terminal fragment, fig. 3 *a*, this double cavity persists as a pair of widely separated tubules. The fine tubercles clustered on the ridges which bound the median groove are pitted on the summit; and the peculiar nature of the ridged and pitted ornament of the greater part of the upper surface is illustrated in the enlarged fig. 3 *d*. In the terminal part of the rostrum the median groove is only slightly marked, and the longitudinal ridges of the ornament extend over it; these ridges are now very conspicuous, often subdivided into tubercles and in places reticulating. The lower surface (fig. 3 *a*) is nearly smooth, but faintly impressed by a median longitudinal groove like that of the upper surface.

Horizon and Locality.—Zone of *Holaster subglobosus*; Betchworth, Surrey.

Family EUGNATHIDÆ.

No typical member of this family has hitherto been found in the Chalk; for the fragment of jaw from the Chalk of Lewes named *Caturus similis* by Agassiz (Poiss. Foss., vol. ii, pt. ii, 1844, p. 118, pl. lxvi *a*, fig. 9) is indeterminable and probably belongs to a Teleostean fish. Two genera, however, *Lophiostomus* and *Neorhombolepis*, from the English Chalk, appear to be highly specialised Eugnathidæ, with completed vertebral centra, and without fulcra on the paired fins.

Genus **LOPHIOSTOMUS**, Egerton.

Lophiostomus, P. de M. G. Egerton, Figs. and Descript. Brit. Organic Remains, dec. vi (Mem. Geol. Surv., 1852), no. 10.

Generic Characters.—Head relatively large, with very wide gape, and apparently much depressed. External head-bones and the opercular bones stout, more or less ornamented with tubercles and rugæ of enamel; also sometimes bearing prominent bosses, notably in one or more pairs on the cranial roof. Maxilla with a straight or slightly concave tooth-bearing border, and the premaxillæ fused together, probably also with the ethmoid; teeth conical, in regular series, large and hollow on the margin of the jaw, minute on the inner bones, not in sockets. Suboperculum nearly half as large as the operculum, which is quadrangular, but truncated at the postero-superior angle; gular plate very large. Vertebral centra apparently ring-shaped. Paired fins without fulcra, and the pelvic pair relatively small and

far forwards; their rays stout and ornamented. Scales rhombic and thick, with a wide overlapped border not produced at the angles, and the peg-and-socket articulation feeble or wanting; superficial ganoine more or less striated or pitted; numerous series of narrow ventral scales.

Type Species.—*Lophiostomus dixonii*, from the English Chalk.

Remarks.—This genus is evidently related both to the Eugnathidæ and to the Amiidæ. Its thick rhombic scales and the presence of bony outgrowths on some of the external plates, considered together, suggest that it is one of the last members of the former family. The terminal forms of a group are often characterised by an armature of bony bosses or spines.

1. **Lophiostomus dixonii**, Egerton. Plate XXXIII, figs. 4, 5.

1852. *Lophiostomus dixonii*, P. de M. G. Egerton, *loc. cit.*, n. 10, pls. x, x*.

1888. *Lophiostomus dixonii*, A. S. Woodward, *Proc. Geol. Assoc.*, vol. x, p. 303.

1895. *Lophiostomus dixonii*, A. S. Woodward, *Catal. Foss. Fishes B. M.*, pt. iii, p. 359.

Type.—Head with part of abdominal region; British Museum.

Specific Characters.—The type species, with skull attaining a length of 6 cm. External bones and fin-rays very conspicuously ornamented. Maximum width of cranial roof exceeding two thirds of its length; a pair of frontal prominences above the hinder part of the orbit, each laterally compressed and much elevated, the height exceeding half the distance between the pair; a similar pair of prominences on the squamosals. Gular plate as long as the tooth-bearing portion of the mandible, and at least two thirds as broad as long. Hinder border of scales with coarse, long, acuminate pectinations, continued on the outer face of the principal scales as oblique wrinkles or elongated pits.

Description of Specimens.—The only satisfactory specimen of this species hitherto discovered is the type (Pl. XXXIII, fig. 4). All other specimens are mere fragments.

All the external bones of the head and opercular apparatus are conspicuously ornamented with coarse and closely arranged tubercles of enamel, which are sometimes elongated as on the preoperculum (fig. 4 *d*), and sometimes fuse into vermiculating ridges as on the mandible, gular plate (fig. 4 *e*) and operculum. This ornament obscures the sutures in the cranial roof, which seems to have been slightly hollowed by a median longitudinal depression. The post-orbital portion of the cranium (fig. 4) is much broader than long, and bears two pairs of prominences, which are situated just above and behind the eyes (*p*.¹) and at the squamosal angles (*p*.²) respectively. These prominences are laterally compressed, ornamented with the usual tubercles of enamel, and inclined backwards (fig. 4 *a*, *p*.¹ *p*.²). The frontal region (*fr*.) scarcely tapers forwards, but terminates shortly in advance of the orbits in a truncated border, which is excavated on either side

for sutural union with the nasal bones (*na.*). In the fossil these elements are slightly displaced, but they are shown to be longer than broad, and they must have met originally in the middle line. Each nasal bears a small rounded boss of enamel near its antero-external angle. The skull is completed in front by a short, broad and rounded bone, in which the two premaxillæ are fused probably with a small mesethmoid (fig. 4, *pmx.*; fig. 4 *c*). The cheek-plates are scarcely known, but among displaced fragments there seems to be an antorbital (fig. 4, *ao.*), which bears a rounded boss of enamel near its antero-inferior angle.

The mandibular suspensorium must have been nearly vertical, and the gape of the mouth is as wide as in *Amia*. The inner bones are unknown; but one regular series of small conical teeth within the maxilla was probably borne by the ectopterygoid, while similar teeth in front belong either to the palatine or vomer. The fused premaxillæ (figs. 4, 4 *a*, *pmx.*; fig. 4 *c*), which are very coarsely ornamented, form a broad and bluntly rounded snout, with a single regular series of about twelve stout, conical teeth. The maxilla (figs. 4, 4 *a*, *mx.*) is stoutest and most coarsely ornamented in front, becoming a wide tuberculated lamina behind. The oral margin is nearly straight, very slightly wavy in the middle (broken on the right side of the fossil, fig. 4 *a*), and bears a single series of conical teeth, which are smaller than those of the premaxilla and become minute behind. The mandibular rami are especially stout, and the peculiar shape of the ramus of the left side is shown from below and in outer view in fig. 4 *b*. The dentary bone (*d.*) forms nearly the whole of its outer face, on which the tubercular ornament is in many parts fused into vermiculating ridges. It bears a single regular series of conical teeth, which are much larger than those of the upper jaw and do not diminish in size backwards. Within the entire length of the dentary there is a single series of minute conical teeth (perhaps the front series of a cluster), which doubtless belong to a splenial element and extend behind up the slight coronoid elevation. All the teeth are hollow cones capped with a point of translucent enamel; and the large mandibular teeth exhibit a feeble vertical fluting in the apical half. They are directly fused with the supporting bone, not in sockets.

The preoperculum (fig. 4, *pop.*), is narrow and gently arched, with the large lower limb blunter than the upper limb, and the angle marked only by a broad horizontal ridge. The tubercles of its ornament are antero-posteriorly elongated (fig. 4 *d*). The operculum (fig. 4, *op.*) must have been about as broad as deep, with its lower border straight and nearly horizontal, and its upper portion rapidly tapering by the truncation of its postero-superior angle. The ornament of its outer face is for the most part fused into a coarse reticulation. The suboperculum (fig. 4, *sop.*) is very broad and not deep; the elongated tubercles of its ornament incline downwards and backwards, and cause its border to be pectinated. A fragment of the interoperculum shows that this element was also highly ornamented. There are remains of thirteen branchiostegal rays (fig. 4 *b*, *br.*), of

which at least ten are supported by the arched ceratohyal (*ch.*). The uppermost rays are ornamented and pectinated like the suboperculum; and only the three lowest rays in the fossil (possibly broken by flaking) are destitute of tubercles. The gular plate (fig. 4*b*, *gu.*) is relatively very large and broad, widest behind, truncated in front, and richly ornamented with tubercles which are often fused into vermiculating ridges (fig. 4*e*).

There are no traces of vertebræ in the type specimen; but two thin and broad vertebral rings, of loose and fibrous texture, occur with a group of scales and a fin-ray obtained by the Earl of Enniskillen from Lewes (B. M. no. P. 4263).

The pectoral arch is scarcely known, but there seems to have been a single pair of ornamented supratemporals, and a bone which may be supraclavicle is pectinated at the hinder border. A large postclavicular plate (fig. 4, *pcl.*) is comparatively smooth, the reticulated ridge-ornament being very feeble. The pectoral fin-rays, of which the bases of seven in series, with three or four others further back, are seen in fig. 4*b* (*pct.*), are stout, closely pressed together, and ornamented with elongated tubercles. The rays of the much smaller pelvic fins (*plv.*), which are far forwards, are similarly stout and highly ornamented, but their enamel-tubercles are fused into vermiculating ridges of mainly oblique direction. There are no traces of fulcræ on the paired fins. The median fins are unknown.

The scales are rhombic and deeply overlapping (fig. 5), with a low and broad vertical ridge on the inner face and a very feeble peg-and-socket articulation (fig. 4*f*). They are scarcely ever deeper than broad, and in most of them the upper and lower borders are sigmoidally curved. So far as known, they are most highly ornamented between the pectoral fins, where they are covered with elongated enamel-tubercles, which are more or less fused into a network and terminate behind in coarse pectinations at the posterior border. All the scales are serrated or pectinated behind, but there is every gradation between the extreme ornamentation of the outer face just described and a smoothness which is only interrupted by pittings. An ordinary scale, with feeble oblique wrinkles in front and elongated pittings and pectinations behind, is shown in fig. 5.

Horizons and Localities.—Turonian zones: neighbourhood of Lewes and Alfriston, Sussex; near Maidstone, Kent.

Genus **NEORHOMBOLEPIS**, A. S. Woodward.

Neorhombolepis, A. S. Woodward, Proc. Geol. Assoc., vol. x, 1888, p. 304.

Generic Characters.—Trunk elongate-fusiform, more or less laterally compressed, and head relatively large. External head-bones and the opercular bones stout, more or less ornamented with tubercles and rugæ of enamel, but no pro-

minent bosses or outgrowths. Maxilla with a straight tooth-bearing border, and a long supramaxillary bone; teeth conical, in regular series, large and hollow on the margin of the jaw, not in sockets. Suboperculum at least half as large as the operculum, which is quadrangular but truncated at the postero-superior angle. Vertebral centra either ring-shaped or completely ossified. Paired fins without fulera, the pectorals with an especially stout preaxial ray. Scales rhombic and thick, with a wide overlapped border not produced at the angles, and the peg-and-socket articulation feeble or wanting; superficial ganoine nearly smooth; few principal flank-scales as deep as broad, the majority broader than deep, and those of numerous ventral series at least twice as broad as deep.

Type Species.—*Neorhombolepis excelsus*, from the English Chalk.

Remarks.—This genus differs from *Lophiostomus* in the less depressed and less shortened form of the head and trunk, and in the absence of bony prominences or bosses on the external bones. It is known only from the English Chalk and from the Wealden formation (*Neorhombolepis valdensis*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iii, 1895, p. 356, pl. viii, fig. 5).

1. *Neorhombolepis excelsus*, A. S. Woodward. Plate XXXIV, fig. 1.

1888. *Neorhombolepis excelsus*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 304, pl. i, fig. 1.

1895. *Neorhombolepis excelsus*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iii, p. 355, pl. viii, fig. 4.

Type.—Imperfect head with abdominal region; British Museum.

Specific Characters.—The type species, with skull attaining a length of about 8 cm. Cranial roof ornamented with closely-arranged elongated tubercles and short rugæ of ganoine; cheek-plates, jaws, and opercular bones more sparsely ornamented. Marginal teeth smooth, tumid at base, slender, and slightly incurved at apex; those of maxilla almost as large as those of dentary. Two anterior pectoral fin-rays closely ornamented. Scales small and smooth, those of the ventral half of the trunk very much elongated, often nearly three times as broad as deep; their hinder border either smooth or with from two to four large denticulations.

Description of Specimen.—This species is still known only by the type specimen, which lacks the snout and the pelvic and paired fins. Its principal characters are shown in Pl. XXXIV, figs. 1—1*f*.

The roof of the skull (figs. 1, 1*a*) is very gently arched from side to side, and its postorbital region is two thirds as long as broad. Its interorbital region is comparatively narrow, and the orbits must have been large. When not flaked away, its constituent bones are shown to be ornamented with closely-arranged, coarse tubercles of ganoine, which are often fused into short vermiculating ridges. The squamosal element (*sq.*), impressed by the transverse slime-canal, is clearly distinguishable, forming each postero-external angle; and the parietals (*pa.*)

constitute the middle part of the hinder border, which is straight and exhibits a wide, smooth surface of overlap for the supratemporals. The large frontal bones (*fr.*) are very wide behind, and are an unsymmetrical pair. As shown in hinder view (fig. 1 *d*), the occiput above the foramen magnum (*f.m.*) is completely ossified, but its constitution is uncertain. The basioccipital (*bor.*) is largely excavated for penetration by the persistent notochord; and the basicranial axis, as far as the front of the orbit, is shown to have been parallel with the cranial roof. The cheek-plates are scarcely known, but they appear to have been more sparsely ornamented with tubercles of ganoine. One postorbital (fig. 1, *po.*) is deeper than broad.

The mandibular suspensorium is vertical or slightly inclined forwards. The inner face of the laminar pterygoid arch is covered with a cluster of small tubercular teeth, which pass at the lower border into very stout conical teeth nearly as large as those on the marginal bones of the jaws. The maxilla (fig. 1, *mx.*) is a long and narrow lamina, marked on the outer face with irregular longitudinal rugæ, and sparsely ornamented with elongated tubercles of ganoine. Its hinder half is excavated above to accommodate the long and narrow supramaxilla (*smx.*), which is similarly ornamented and is pointed at each end. The oral margin of the bone is nearly straight, and bears a regular close series of slender conical teeth, which are slightly curved inwards at the apex. The mandible (fig. 1, *md.*; fig. 1 *b*) is slender, but elevated in the coronoid region, where a large surangular (*sag.*) articulates with the bifurcated end of the dentary. Except near the oral border, the outer face of the dentary bone is more closely ornamented than that of the maxilla, and many of its tubercles are fused into longitudinal ridges. Its closely set teeth resemble those of the maxilla, but are perhaps stouter. The splenial bone is unknown. All the teeth are smooth, hollow cones, more or less tumid at the base, and usually capped with a small point of translucent enamel. They are directly fused with the supporting bone, not in sockets.

The opercular apparatus is only imperfectly known, but the operculum (*op.*) and suboperculum (*sop.*), with broad branchiostegal rays below, are seen in a fragmentary state on the right side of the fossil (fig. 1). The operculum is deeper than broad, while the suboperculum is relatively large; and there are indications that the outer face of these bones was sparsely ornamented like the cheek-plates. Part of the large gular plate clearly shows such ornament.

It is difficult to interpret the remains of the vertebral column, which are seen only in section; but the centra (fig. 1 *c*) appear to have been thin broad rings of loose and fibrous texture.

The pectoral arch is not seen in the type specimen, but appended to it are post-clavicular plates (fig. 1, *pcl.*). These are arranged as they usually appear in the Eugnathidæ, and the two lower plates exhibit a conspicuous ornament of tubercles and ridges directed antero-posteriorly. The surface of the two upper

plates seems to have been flaked away in the fossil. Twelve rays, with long unjointed bases and remains of closely articulated distal ends, are preserved in the pectoral fin (*pct.*). The foremost ray is especially stout, with its articular end projecting upwards above the others. This ray and the second bear traces of a tubercular ornament.

Probably all the scales preserved belong to the lower half of the flank, but they are especially remarkable for their elongated shape. They are all rhombic in form, with a straight overlapped margin, and with the hinder border curiously variable, sometimes entire or produced only at the lower angle (fig. 1 *f*), sometimes with from two to four denticulations (fig. 1 *e*). Their smooth enamelled surface is marked only by occasional fine pittings. Two or three scales exhibit a large median perforation for the passage of a slime-canal.

Horizon and Locality.—Zone of *Holaster subglobosus*: Halling, Kent.

2. *Neorhombolepis* (?) *punctatus*, A. S. Woodward. Plate XXXIV, fig. 2.

1844. *Lepidotus punctatus*, L. Agassiz, Poiss. Foss., vol. ii, pt. i, p. 306 (name only).

1844. *Lepidotus punctulatus*, L. Agassiz, *tom. cit.*, pt. ii, p. 287 (name only).

1888. *Genus non det.*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 304, pl. i, fig. 2.

1895. *Neorhombolepis* (?) *punctatus*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iii, p. 357

Type.—Scales from zone of *Holaster subglobosus*; British Museum.

Specific Characters.—Larger than *N. excelsus*, the breadth of the exposed part of the largest known scale being 15 mm. External face of scales covered with smooth ganoine, marked with a few pittings in the posterior triangular area of which the centre is the apex; hinder border not serrated or crenulated.

Description of Specimens.—In the type specimen from Burham in the Enniskillen Collection (B. M. no. P. 4705) no scale is deeper than broad, and the majority are much broader than deep. It is clear that the wide overlapped margin is straight, not produced forwards at its angles; and the very feeble peg-and-socket articulation is shown. The external enamel is fractured and not well preserved, though it exhibits the characteristic triangular area marked by pittings. This feature is still better seen in some well-preserved scales (Pl. XXXIV, figs. 2, 2 *a*) discovered by Mr. S. J. Hawkins also at Burham.

The form of their overlapped margin shows that these scales do not belong to a species of *Lepidotus*; but their reference to *Neorhombolepis* is only provisional.

Horizon and Localities.—Zone of *Holaster subglobosus*: Burham, Kent; Dorking, Surrey; Louth, Lincolnshire (Rev. C. R. Bower).

Family SEMIONOTIDÆ.

It is doubtful whether *Lepidotus* or allied genera survived into the Upper Cretaceous, but some scales from the Chalk Marl appear to represent one of these fishes.

Genus **LEPIDOTUS**, Agassiz.

Lepidotus, L. Agassiz, Neues Jahrb., 1832, p. 145 (*Lepidotes*), and Poiss. Foss., vol. ii, pt. i, 1833, pp. 8, 233.

Generic Characters.—Trunk fusiform and only moderately compressed. Marginal teeth robust, styliform; inner teeth stouter, often rounded but smooth. Opercular apparatus well developed, with a narrow arched preoperculum, but with few branchiostegal rays and no gular plate. Fin-fulcra very large, in a double series on all the fins. Paired fins small; dorsal and anal fins short and deep, the former opposed to the space between the latter and the pelvic fins; caudal fin slightly forked. Scales very thick, smooth or feebly ornamented; flank-scales not much deeper than broad, with their wide overlapped margin produced forwards at the superior and inferior angles; scales of the ventral aspect not much broader than deep; dorsal and ventral ridge-scales usually inconspicuous.

1. **Lepidotus (?) pustulatus**, A. S. Woodward. Plate XXXV, figs. 1—4.

1895. *Lepidotus (?) pustulatus*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iii, p. 121, pl. viii, fig. 1.

Type.—Group of scales; British Museum.

Specific Characters.—A large species known only by scales, which sometimes measure 35 mm. in length in their exposed portion. Scales moderately stout, with a thin and sometimes discontinuous layer of enamel, marked by irregularly arranged, large, round shallow pits and pustules; principal flank-scales exhibiting a few broad ridges and furrows radiating from the centre to the hinder border, where they form feeble digitations; several scales much broader than deep.

Description of Specimens.—The scales generally resemble those of some of the large Upper Jurassic species of *Lepidotus*, but are characterised by their peculiar, sparse pustulation. The enamel on their outer face is always extremely thin, except round the margin; their peg-and-socket articulation is very feeble, and their inner face is at most only gently tumid, not ridged. Their overlapped border is very wide, and sometimes shows its forward production at the angles (Pl. XXXV,

figs. 1, 2). The principal flank-scales are not deeper than broad, and the number of the radiating grooves with which they are marked does not exceed eight or nine (fig. 3). The ventral scales are sometimes more than twice as broad as deep, and their outline is more or less sigmoidal. The number of the radiating grooves is comparatively few. On some scales these grooves are almost obsolete, and there is instead a slight keel extending obliquely upwards and forwards from the postero-inferior angle (fig. 4). One large and flattened median scale, probably from the anal region, is marked behind by four short radiating grooves (see Catal. Foss. Fishes B. M., pl. viii, fig. 1 *h*).

A piece of external bone, apparently found associated with the type specimen, is marked with coarse, radiating ridges, on which small tubercles or pustulations are irregularly arranged. It is not enamelled.

Horizon and Locality.—Zone of *Schloenbachia varians*: Folkestone, Kent.

Family PYCNODONTIDÆ.

Most of the remains of Pycnodont fishes hitherto obtained from the English Chalk are so fragmentary that they cannot be generically determined. The only important specimens are those of *Anomæodus*.

Genus **ANOMÆODUS**, Forir.

Anomæodus, H. Forir, Ann. Soc. G  ol. Belgique, vol. xiv, 1887, M  m., p. 25.

Generic Characters.—Head-bones ornamented with reticulating rug  . Oral surface of vomer nearly flat, with teeth of irregular sizes in from three to five longitudinal series; splenial dentition restricted to a space considerably separated throughout its extent from the thin oral border of the bone, comprising one principal series of teeth, flanked within by at least one small series and outside by two or more small series; all the principal teeth smooth or with a very feeble linear indent. Scales restricted to part of the abdominal region; all ornamented with reticulating rug  .

Type Species.—*Anom  odus subclavatus* (*Pycnodus subclavatus*, L. Agassiz, Poiss. Foss., vol. ii, 1833–44, pt. i, p. 17; pt. ii, p. 198, pl. lxxii *a*, fig. 59), from the Upper Cretaceous (Danian) of Maastricht, Holland.

Remarks.—The Pycnodontid   attained their chief development in the Jurassic period, and the Upper Cretaceous *Anom  odus* must be regarded as a degenerate member of the family. The teeth differ from those of other genera in not extending to the outer border of the splenial bone, and they are very irregular in their arrangement. The scales in the only species in which they are known

are absent on the tail and do not appear to have covered the whole of the abdominal region.

1. **Anomæodus angustus** (Agassiz). Plate XXXIV, figs. 3, 4.

- 1837-44. *Gyrodus angustus*, L. Agassiz, Poiss. Foss., vol. ii, pt. ii, pp. 235, 246, pl. lxvi a, figs. 14, 15.
 1839-44. *Pycnodus cretaceus*, L. Agassiz, *ibid.*, p. 198, pl. lxxii a, fig. 60.
 1833-44. *Pycnodus angustus*, L. Agassiz, *ibid.*, pt. i, p. 17, pt. ii, p. 199 (name only).
 1844. *Pycnodus elongatus*, L. Agassiz, *ibid.*, p. 199 (name only).
 1850. *Gyrodus angustus*, F. Dixon, Geol. Sussex, p. 370, pl. xxx, fig. 14, pl. xxxiii, fig. 1.
 1888. *Cælodus angustus*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 307.
 1888. *Cælodus cretaceus*, A. S. Woodward, *ibid.*, p. 308.
 1895. *Anomæodus angustus*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iii, p. 260.

Type.—Splénial teeth from a Turonian zone at Houghton, Sussex; British Museum.

Specific Characters.—Teeth of the principal series on the splénial bone very obliquely set, truncated at their outer extremity, rapidly tapering to a blunt point at the inner extremity, and when young and unworn marked with a slight transverse coronal furrow; inner teeth in two irregular series, those of the first elongated, those of the innermost much smaller and round, both deeply pitted and with crenulated margin; teeth of the flanking series in about three or four very irregular rows, all deeply pitted and with crenulated margin, the innermost transversely elongated and much larger than any of the others, which are rounded. Scales marked with coarse reticulations; serrations of the ventral ridge-scales conspicuous, long and slender.

Description of Specimens.—The type specimen is a row of principal splénial teeth, sufficiently resembling the corresponding teeth in part of a fish figured by Dixon, *op. cit.*, to permit the reference of the latter specimen to the same species. Several of the most important characters of the species are therefore known.

The fossil figured by Dixon is in two pieces, the one showing a series of neural arches with the upper ends of the ribs, the other partly re-drawn in Pl. XXXIV, fig. 3, displaying the lower half of the greater portion of the fish with both splénial bones and a fragment of the skull. The usual bony laminæ on the neural and hæmal (*h.*) arches are large, extending from one arch to the next but not interdigitating. There are traces of them even on the ribs. The bases of the neural and hæmal arches do not completely surround the notochord, and there is no interlocking. About twenty-five supports for the anal fin (*a.*) are seen, but no other traces of fins are preserved. The scales are coarsely reticulated like the scales of a crocodile, and cover the lower part of the abdominal region in front of the anal fin. The ventral ridge-scales (*v.*) are at least as wide as deep, and armed with a close series of backwardly turned sharp spinelets, which

form a conspicuous serration. The scales of the next row are much deeper than wide, with the upper end rounded or truncated. Above these the scales are doubled in depth, and rapidly taper to a blunt point at the upper end. Next there is a row of still more deepened scales, which are remarkably slender and tapering in their upper two thirds, and appear to terminate the squamation of the flank.

The vomer is unknown, but both the splenials are exhibited in Dixon's fossil, and that of the right side is shown in Pl. XXXIV, fig. 3*a*. In Dixon's original figure the bones are somewhat diagrammatically restored, and two oval vacuities are wrongly represented in the outer toothless margin. This margin forms a thin, smooth lamina with a very sharp edge, without any vacuity. In the front third of the bone all the teeth are small and rounded, each with an apical pit; but behind these the characteristic row of principal teeth is seen in regular order. In the left splenial, the two posterior principal teeth are less elongated than the others and irregular in shape. In a larger specimen from Houghton figured by Dixon (*op. cit.*, pl. xxx, fig. 14), the principal teeth are in a remarkably regular series and approach the fragment of splenial dentition named *Pycnodus cretaceus* by Agassiz. There is, in fact, every gradation between the typical *A. angustus* and the latter form. A very small left splenial dentition from the Grey Chalk of Folkestone (Pl. XXXIV, fig. 4) is also probably referable to the young of this species. It shows very well the beginning of the row of principal teeth, each with a very shallow apical hollow; it also exhibits a crimping of the margin of the pitted crown in the smaller teeth (fig. 4*a*).

Horizons and Localities.—Turonian zones: neighbourhood of Lewes, Newtimber, and Houghton, Sussex. Zone of *Micraster coranquinum*: Northfleet, Kent; South Croydon, Surrey. Zone of *Micraster cortestudinarium*: Purley, Surrey; Borstal, Kent. Zone of *Schloenbachia varians*: Folkestone.

2. *Anomæodus willetti*, A. S. Woodward. Plate XXXIV, fig. 5.

1893. *Anomæodus willetti*, A. S. Woodward, Geol. Mag. [3], vol. x, p. 489, pl. xvii, fig. 1.

1895. *Anomæodus willetti*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iii, p. 263.

Type.—Imperfect skull with dentition, from the zone of *Holaster subglobosus*; Brighton Museum.

Specific Characters.—A small species, with teeth very irregularly arranged. Teeth of the principal series on the splenial bone obliquely set, very irregular in size and shape, wide mesially, tapering at each extremity, and not much broader than long; inner teeth relatively large, in one series, usually broader than long, with axis oblique; outer teeth in about three very irregular series, mostly smaller than the teeth of the inner series. Vomerine dentition anteriorly in three series, posteriorly in five, but extremely irregular; the largest teeth much antero-

posteriorly elongated and comprised in the outermost series. Nearly all the teeth indented, the smaller ones having the pit especially conspicuous and surrounded with a crenulated margin.

Description of Specimen.—This species is still known only by the type specimen, which is important as exhibiting some features in the cranial osteology of the fish. The skull is much elongated, and the snout must have been acutely pointed. The mesethmoid forms a stout median septum in the rostral region, and unites in an extended suture with the vomer below. At the hinder end of the vomer, a short distance beyond its dentition, the pterygo-quadrato palatine arcade is shown as a continuous, inwardly curved thin plate of bone fused with the base of the skull, perhaps with the edge of the parasphenoid. It is toothless. A thin median keel extends along the lower face of the parasphenoid. The structure of the mandible (Pl. XXXIV, fig. 5) is not clear, but its articular element exhibits a very deep undulating facette (*art.*), and on the splenial (*spl.*) the teeth are restricted to a surface considerably within the external margin of the bone.

The vomerine teeth (fig. 5 *a*), as mentioned in the specific diagnosis, are remarkably irregular in size and arrangement. They appear to begin as three longitudinal series, but these soon become indefinite; and it is curious that the largest teeth are not in the middle, but in the marginal row. The splenial dentition (fig. 5) is noteworthy for the very slight differentiation of a principal series of teeth.

Horizon and Locality.—Zone of *Holaster subglobosus*: Glynde, Sussex.

Genus **CÆLODUS**, Heckel.

Cœlodus, J. J. Heckel, Denkschr. k. Akad. Wiss., math.-naturw. Cl., vol. xi, 1856, p. 202.

Glossodus, O. G. Costa (*non* M'Coy, 1848), Atti Accad. Pontan., vol. vii, 1853, p. 26.

Cosmodus, H. E. Sauvage, Bull. Soc. Sci. Nat. Yonne, vol. xxxiii, pt. ii, 1879, p. 48.

Generic Characters.—Trunk very deeply fusiform, with slender abbreviated caudal pedicle. Head and opercular bones externally rugose and punctate; most of the teeth exhibiting an apical indent with crenulated border; oral surface of vomer strongly convex from side to side, with teeth in five longitudinal series; splenial dentition comprising three series of teeth with long axes directly transverse, sometimes supplemented within by a small row, and all the outer teeth showing frequent tendency to irregular subdivision. Neural and hæmal arches of axial skeleton of trunk not expanding sufficiently to encircle the notochord. Fin-rays robust, closely articulated, and much divided distally. Pelvic fins present; dorsal and anal fins high and acuminate in front, low and fringe-like behind, the former occupying at least the hinder half of the back and the latter somewhat shorter, arising more posteriorly; caudal fin deeply forked, with a convexity in

the middle. Scales ornamented with reticulating rugæ and punctations, and occupying only the anterior half of the trunk in advance of the median fins.

Type Species.—*Cœlodus saturnus* (Heckel, *loc. cit.*, 1856, p. 207, pls. iii, iv), known by a nearly complete fish from the Lower Cretaceous of Goriansk, Istria.

Remarks.—Though found sometimes also in the Upper Jurassic, this is a typically Cretaceous genus. Many nearly complete skeletons are known,¹ but only jaws have hitherto been discovered in the English Chalk.

1. *Cœlodus parallelus* (Dixon). Text-figure 46.

1850. *Pycnodus parallelus*, F. Dixon, Geol. Sussex, p. 369, pl. xxxiii, fig. 3.

1888. *Cœlodus parallelus*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 308.

Type.—Imperfect splenial dentition; Brighton Museum.

Specific Characters.—A large species known only by the splenial dentition. Teeth of principal series on the splenial bone smooth, somewhat more than three

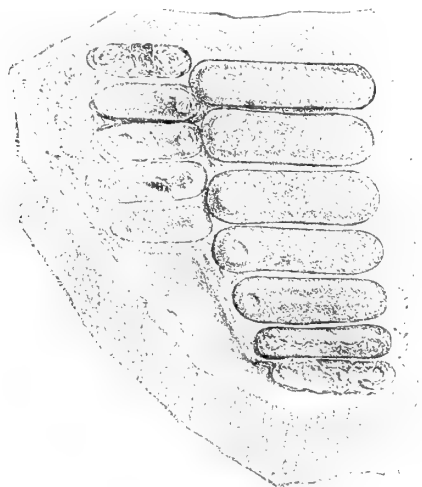


FIG. 46. *Cœlodus parallelus* (Dixon); right splenial dentition, nat. size.—Chalk: Southeram, Lewes. After Dixon.

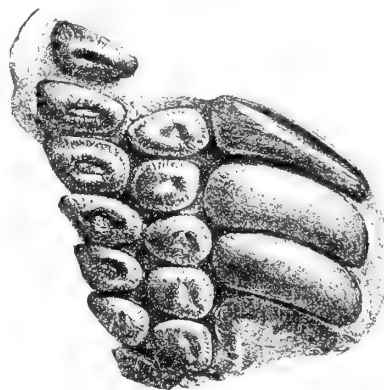


FIG. 47. *Cœlodus fimbriatus*, A. S. Woodward; right splenial dentition, nat. size.—Zone of *Holaster subglobosus*; Halling, Kent. Wetherell Collection (B. M. no. 43090).

times as broad as long; those of the inner flanking series considerably more than half as broad as the latter.

Horizon and Locality.—A Turonian zone: Southeram, near Lewes.

2. *Cœlodus fimbriatus*, A. S. Woodward. Text-figure 47.

1893. *Cœlodus fimbriatus*, A. S. Woodward, Geol. Mag. [3], vol. x, p. 491, pl. xvii, fig. 6.

Type.—Right splenial dentition; British Museum.

¹ In addition to the references given in Catal. Foss. Fishes B. M., pt. iii, see also C. Gorganovic-Kramberger, Djela Jugoslav. Acad., vol. xvi, 1895, p. 19.

Specific Characters.—A large species known only by the splenial dentition. Teeth of principal series on the splenial bone smooth or feebly crimped round the margin, somewhat less than three times as broad as long, about equalling in width the two outer series, which are nearly similar in size, irregular in form, slightly broader than long, and having a deep coronal pit with rugose or crimped margin.

Horizon and Locality.—Zone of *Holaster subglobosus*: Halling, Kent.

PYCNODONT TEETH OF UNCERTAIN GENERIC POSITION.

1. **Gyrodus (?) cretaceus**, Agassiz. Plate XXXV, figs. 5—7.

1833–39. *Sphærodus mammillaris*, L. Agassiz, Poiss. Foss., vol. ii, pt. i, p. 15 (in part), pl. lxxiii, figs. 1, 2.

1839–44. *Gyrodus cretaceus*, L. Agassiz, *ibid*, vol. ii, pt. ii, p. 233, pl. lxix a, fig. 13.

1840. *Gyrodus cretaceus*, R. Owen, Odontography, p. 72.

1844. *Gyrodus mammillaris*, L. Agassiz, *op. cit.*, vol. ii, pt. ii, p. 236.

1844. *Pycnodus marginalis*, L. Agassiz, *op. cit.*, vol. ii, pt. ii, p. 199.

1850. *Gyrodus cretaceus*, F. Dixon, Geol. Sussex, p. 370, pl. xxx, fig. 15.

1850. *Gyrodus conicus*, F. Dixon, *ibid.*, p. 370, pl. xxxii, fig. 8.

1888. *Gyrodus cretaceus*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 308.

1895. *Gyrodus (?) cretaceus*, A. S. Woodward, Catal. Foss. Fishes B.M., pt. iii, p. 245.

Type.—Portion of vomerine dentition.

Specific Characters.—Dental crowns much elevated, obtusely acuminate, and coarsely rugose; those of the median and outer paired series on the vomer usually longer than broad, about equal in size; teeth of inner paired series on this bone relatively small and multiplied in the adult.

Description of Specimens.—The type specimen, said to have been in the Mantell Collection, cannot be found; and the portion of splenial dentition named *Gyrodus conicus* by Dixon is not traceable. The isolated teeth named *Sphærodus mammillaris* and *Pycnodus marginalis* have also been lost. Good examples of the vomerine dentition, however, are known, and there is one fragment apparently of the splenial dentition.

The best specimen of vomerine teeth, already figured by Dixon, is shown again in Pl. XXXV, fig. 5. All the teeth are more or less conical and rugose, often with a flattened rim or cingulum; and some of the smaller teeth are mammilliform, their median boss being rounded and sharply defined. When they are worn their internal cavity is soon exposed at the apex, and the abraded surface of the dentine is coarsely punctate. Their arrangement is remarkably irregular, and the inner paired series is represented on each side by more than one row of teeth. The teeth of the median series are not larger than those of

the outer paired series; they are usually a little longer than wide, and in the specimen figured they are reduced in size behind. The teeth of the outer paired series are steepest at the external face, and descend to a wide cingulum within. This cingulum is especially wide in a smaller (younger) specimen of the vomerine dentition from Guildford (B. M. no. 49802), and the outer lateral teeth are slightly larger than the median teeth. A still smaller specimen (Pl. XXXV, fig. 7), probably of the same species, shows only the three principal rows of teeth, with the beginning of an inner paired series of small teeth behind. Here the teeth exhibit a coarsely punctate surface, as if their external layer had been removed.

In a supposed fragment of the splenial dentition of the same species (Pl. XXXV, fig. 6), the apex of each tooth in the principal series projects forward and is continued behind into a short keel. There are a few relatively small mammilliform teeth on each side.

Remarks.—Some oval *Gyrodus*-like teeth figured by Dixon (*op. cit.*, pl. xxxii,* fig. 6) seem to resemble very closely those just described, but their ornament is represented as consisting of radiating lines of ill-defined tubercles. They are named *Gyrodus dixonii* by W. A. Ooster, *Protozoë Helvetica*, vol. ii, 1870, p. 46.

Horizons and Localities.—Turonian zones: neighbourhood of Lewes. Zone of *Terebratulina gracilis*: Warlingham, Surrey. Also Chalk near Guildford.

2. *Pycnodus scrobiculatus*, Reuss.

1845. *Pycnodus scrobiculatus*, A. E. Reuss, *Verstein. böhm. Kreideform.*, pt. i, p. 10, pl. iv, figs. 15—25.

1875. *Pycnodus scrobiculatus*, H. B. Geinitz, *Palæontogr.*, vol. xx, pt. i, p. 301, pl. lxx, figs. 22—32.

1893. *Pycnodus scrobiculatus*, A. S. Woodward, *Geol. Mag.* [3], vol. x, p. 492, pl. xvii, fig. 2.

1895. *Pycnodus scrobiculatus*, A. S. Woodward, *Catal. Foss. Fishes B. M.*, pt. iii, p. 281.

Type.—Teeth from the Cenomanian of Bohemia.

Specific Characters.—Teeth tumid and much resembling those named *Gyrodus* (?) *cretaceus*, closely arranged in three longitudinal series on a narrow vomer. Median and lateral vomerine teeth about equal in size, the former with a shallow pit at the apex, the latter truncated at their outer border.

Description of Specimens.—The examples of this species are always very small, and may belong to an immature fish. The specimen described and figured *loc. cit.* 1893 exhibits well the shallow pit in the median teeth. All the teeth are longer than wide.

Horizon and Locality.—Probably zone of *Holaster subglobosus*: Charing, Kent.

3. *Phacodus punctatus*, Dixon. Plate XXXIV, figs. 7, 8.

1850. *Phacodus punctatus*, F. Dixon, *Geol. Sussex*, p. 371, pl. xxx, fig. 16.

Type.—Worn teeth; British Museum.

Specific Characters.—Principal teeth ovoid, with gently rounded smooth crown; lateral teeth irregularly rounded, also with low, smooth crown.

Description of Specimens.—The type specimen (Pl. XXXIV, fig. 7) comprises six teeth probably of the splenial dentition, all much abraded or worn and showing a punctate surface. The teeth of the principal series are scarcely twice as wide as long, while the three lateral teeth are very irregular.

It seems probable that the vomerine dentition shown in Pl. XXXIV, fig. 8, belongs to the same species, although it does not clearly show the punctate structure where the teeth are worn. The median teeth are much less than twice as wide as long, and they are flanked by only one paired series, which is considerably destroyed by wear in the fossil. The large pulp-cavity is conspicuous in many of the teeth. A smaller vomerine dentition in the Capron Collection (B. M. no. 49803) is very similar in general character, but has the teeth more crowded.

Horizons and Localities.—Probably a Turonian zone: Lewes. Chalk: Gravesend, Kent; Dorking, Surrey.

4. *Acrotemnus faba*, Agassiz. Plate XXXIV, fig. 6.

1837–44. *Acrotemnus faba*, L. Agassiz, Poiss. Foss., vol. ii, pt. ii, p. 203, pl. lxvi a, figs. 16–18.

1887. *Celodus faba*, K. A. von Zittel, Handb. Palæont., vol. iii, p. 249.

Type.—Teeth; British Museum.

Specific Characters.—Principal teeth smooth and bean-shaped, each with a sharp keel-like coronal summit overhanging a slight indent which has a feebly crimped inferior margin.

Description of Specimen.—The type is still the only known specimen, and comprises five teeth, all similar to that shown from the oral and posterior aspect in Pl. XXXIV, figs. 6, 6 a. These teeth probably belong to the splenial bone. They are noteworthy for their smooth surface of dense enamel.

Horizon and Locality.—Chalk: Lewes.

Prehensile front teeth of Pycnodonts are also found in the Chalk, and one such specimen is shown in Pl. XXXV, fig. 8. They are slightly hooked, laterally compressed, and somewhat constricted at the base of the crown, which is often crimped.

Among the fragments of Pycnodonts which are generically indeterminable, may also be mentioned the so-called *Microdon occipitalis* (Dixon, Geol. Sussex, 1850, p. 369, pl. xxxii,* fig. 2). It is part of a small fish from the Chalk of Malling, near Lewes, in the Brighton Museum (Willett Collection, no. 104).

Suborder CHONDROSTEI.*Family* POLYODONTIDÆ.*Genus* **PHOLIDURUS**, A. S. Woodward.

Pholidurus, A. S. Woodward, Proc. Geol. Assoc., vol. xi, 1889, p. 31.

Generic Characters.—Not satisfactorily known. Caudal fulcral scales much resembling those of *Psephurus*, but broader and flatter, less pointed, and evidently indicating a stout, depressed fish. Caudal fin-rays coated with ganoine.

1. **Pholidurus disjectus**, A. S. Woodward. Text-figure 48.

1889. *Pholidurus disjectus*, A. S. Woodward, *loc. cit.*, p. 31, pl. i, figs. 4, 5.

1895. *Pholidurus disjectus*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iii, p. 47.

Type.—Fragment of tail; British Museum.

Specific Characters.—The type species. Caudal fulcral scales very flat, with rounded and obtuse apex; their exposed surface ornamented with thick ganoine in irregular dots and short wavy lines, more or less clustered, especially near the margin. Caudal fin-rays very stout, the superficial ganoine thick and rugose, not always completely covering the exposed faces of the successive joints.

Description of Specimen.—The type specimen is still the only known fragment

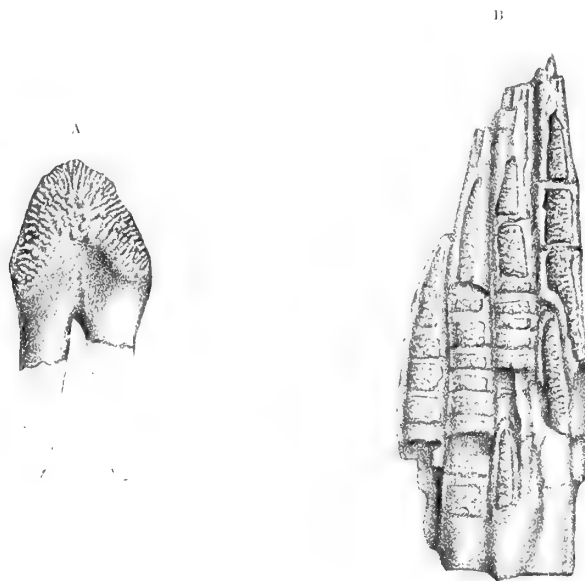


FIG. 48. *Pholidurus disjectus*, A. S. Woodward; caudal fulcral scale (A) and base of some caudal fin-rays (B), nat. size.—Chalk; Gravesend. (B. M. nos. 33221–24.)

of this species, and comprises merely a few fulcral scales and portions of the stout rays of a caudal fin. One of the fulcral scales is shown of the natural size in Text-

fig. 48 A, the bifurcated inserted portion being restored in outline from another example. A still larger fulcral scale measures 24 mm. in maximum width and 27 mm. from the apex to the bifurcation of the base. All these scales are deeply overlapping, relatively broad and remarkably flat; while their apex is rounded and obtuse. Their characteristic ornament is well shown in the figure. The stout fin-rays (Text-fig. 48 B) begin to be very closely articulated at a short distance from the base. Their superficial ganoine is thick and rugose, but does not always extend completely to the edges. No oat-shaped scales for the side of the upper caudal lobe can be distinguished.

Remarks.—Though so imperfect, the fossil thus described is almost certainly a fragment of a sturgeon allied to *Psephurus* and *Polyodon*. It is curious that no other remains of a fish of the same family have hitherto been found in Cretaceous formations in any part of the world.

Horizon and Locality.—Probably zone of *Micraster coranguinum*: Gravesend, Kent.

Order CROSSOPTERYGII.

Suborder ACTINISTIA.

Family CÆLACANTHIDÆ.

Genus **MACROPOMA**, Agassiz.

Macropoma, L. Agassiz, Poiss. Foss., Feuille., 1835, p. 55.

Generic Characters.—Cranial roof-bones externally pitted and tuberculated; the other membrane-bones externally tuberculated, and the scales ornamented with hollow, enamelled, elongated denticles. Maxillæ with irregularly arranged large and small conical teeth; vomerine and palatine teeth large and clustered; pterygo-suspensorium covered internally with granules, which pass into small conical teeth on the lower margin of the bone; dentary toothless; splenial with small conical teeth. The rays of all the fins robust and straight, not expanded, and only articulated for a relatively short extent distally; a double series of small, upwardly-pointing denticles on almost all the rays of the anterior dorsal and caudal fins; pelvic fins opposed to space between the two dorsals; anal fin slightly behind the posterior dorsal; tail tapering, without supplementary caudal fin.

Type Species.—*Macropoma mantelli*, from the English Chalk.

1. **Macropoma mantelli**, Agassiz. Plate XXXV, figs. 9, 10; Plates XXXVI, XXXVII, XXXVIII, figs. 1—5. Text-figures 49, 50.

1822. *Amia? lewesiensis*, G. A. Mantell, Foss. South Downs, p. 239, pls. xxxvii, xxxviii.
 1835–1844. *Macropoma mantelli*, L. Agassiz, Poiss. Foss., Feuille, p. 55, and vol. ii, pt. ii, p. 174, pl. lxx, a (*bis*)—d.
 1849. *Macropoma mantelli*, W. C. Williamson, Phil. Trans., p. 462, pl. xlii, figs. 25, 26, pl. xliii, figs. 27—30.
 1850. *Macropoma mantelli*, F. Dixon, Geol. Sussex, p. 368, pl. xxxiv, fig. 2.
 1866. *Macropoma mantelli*, T. H. Huxley, Figs. and Descrip. Brit. Organic Remains (Mem. Geol. Surv.), dec. xii, p. 27, pls. vii, viii.
 1888. *Macropoma mantelli*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 303.
 1891. *Macropoma mantelli*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. ii, p. 416, pl. xiv, fig. 3.
 1907. *Macropoma mantelli*, A. S. Woodward, Quart. Journ. Geol. Soc., vol. lxiii, p. 136, pl. viii, figs. 7, 8.

Type.—Nearly complete fish (Pl. XXXVI, fig. 1); British Museum.

Specific Characters.—The type species, attaining a length of about 60 cm. Length of head with opercular apparatus about equalling the maximum depth of the trunk, and contained four times in the total length of the fish. All external bones ornamented with fine rounded tubercles of ganoine; the cranial roof-bones and the cheek-plates exhibiting in part also a coarsely reticulate or spongy surface. Operculum not quite two thirds as wide as deep; each gular plate about four times as long as wide. Anterior dorsal fin with eight rays; caudal fin with about twenty rays above and below. All scales covered with hollow spinelets and elongated tubercles of ganoine; on each scale behind the middle of the abdominal region, a median horizontal series of two or three spinelets relatively large and prominent; the scales of the lateral line between the lobes of the caudal fin extensively smooth and thickened.

Description of Specimens.—The general proportions of the fish and many of its special characters are exhibited by the type specimen in the Mantell Collection (Pl. XXXVI, fig. 1), which still remains the most nearly complete example known. This is supplemented by numerous important specimens especially in the British Museum, the Brighton Museum (Willetts Collection), and the Sedgwick Museum, Cambridge. There is thus ample material to justify nearly all parts in the restoration of the skeleton of the species attempted in Text-fig. 49, p. 173.

The chondrocranium is extensively ossified, especially in the otic region, which has already been described by Huxley, *loc. cit.*, but, as shown by a fossil in the Mantell Collection (B. M. no. 4246), there is no firm union between the parietal roof-bones and the underlying elements, while, as proved by many specimens (*e.g.* Pl. XXXVII, fig. 1), there is no ossified interorbital septum. The prefrontal (ectethmoidal) region is evidently ossified, but its shape and proportions are uncertain. The membrane-bones of the cranial roof (Pl. XXXV, figs. 10, 10a,

Family CELACANTHIDÆ.—Genus **MACROPOMA**, Agassiz.

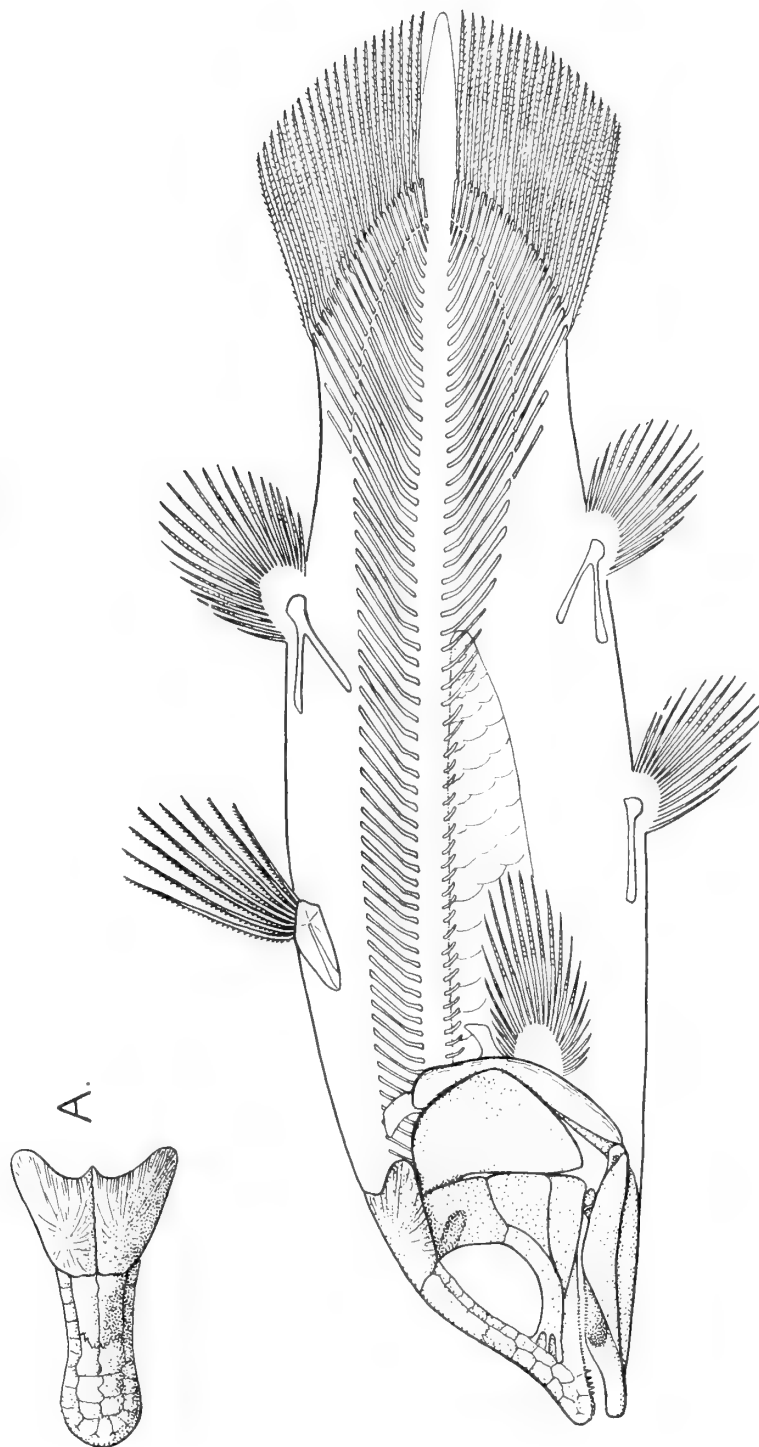


FIG. 49. *Macropoma mantelli*, Agassiz; restoration, without scales, about one third nat. size.—English Chalk.
A. Upper view of skull.

and Text-fig. 49A), as usual in Coelacanths, form a continuous shield, the parietal region being in a plane nearly parallel with the basicranial axis, the longer and narrower fronto-ethmoidal region descending from this at a sharp angulation and ending in a somewhat spatulate snout. The parietal region (*pa.*) is twice as wide behind as in front, and its maximum width somewhat exceeds its length. Its hinder margin is excavated by a re-entering angle, into the middle of which a small point projects backwards; its short anterior margin unites in a straight, transverse suture with the frontal region. Transversely it is strongly convex, with a mesial flattening, and its outer surface is more or less spongy in texture, with a longitudinally-fibrous tendency near the hinder margin, the whole ornamented with sparse, small tubercles of ganoine. It is divided by a straight, median, longitudinal suture, which always persists; and its postero-lateral prominences are also probably separated by suture, though this is not clear. The frontals (*fr.*), similarly divided by a straight, median, longitudinal suture, are relatively small, and their tumid surface is nearly smooth, though sparsely covered with tubercles of ganoine. Together they are longer than wide, and they unite in front in a conspicuously dentated suture with the large, irregular plates on the ethmoidal region (*eth.*). Of these plates there are about three successive pairs in advance of the frontals, and round them are arranged smaller irregular plates, which also extend backwards in a single series along each outer edge of the frontals as far as the parietals. Nearly all the plates are more or less coarsely pitted, though they bear the usual sparse ornament of tubercles. The parasphenoid, which forms a nearly straight basicranial axis, is a very narrow bar in the interorbital region (Pl. XXXVII, fig. 1, *pas.*), but expands forwards into a long spatulate area, densely covered with minute tubercular teeth, which are slightly enlarged along the margin of the bone (Pl. XXXVII, fig. 2). Immediately in advance of the parasphenoid, just below and in front of the prefrontal ossification, there is another expanded bone bearing a cluster of larger blunt teeth, which are hollow and smooth and often exhibit wear at the apex. This bone (Pl. XXXVII, figs. 3, 3 *a*) is comparatively thick, especially at its outer angles, and appears to consist of a pair of elements fused together, probably the coalesced vomers. Its oral face (fig. 3 *a*) is nearly triangular in shape, twice as wide as long, with the apex forwards. The cheek is covered with bony plates, of which the narrow, arched suborbital is always the most conspicuous. This plate (Pl. XXXV, figs. 9, 10, *so.*; Pl. XXXVI, fig. 1, *so.*), which is nearly uniform in width, except at its anterior expansion, is of loose texture, coarsely pitted on its outer face and excavated in front with two deep cavities, which indicate a considerable development of the slime-apparatus. It is ornamented with a few sparse tubercles. There are three postorbitals, which are always imperfect in the fossils, but seem to have been arranged as shown in Text-fig. 49. The upper plate (Pl. XXXV, figs. 9, 10, *po'*.; Pl. XXXVI, fig. 1, *po'*.) is the largest, at least as deep as wide, and nearly square, but slightly produced at its antero-

inferior angle to meet the end of the suborbital. Like the latter element, it is of very open texture, with only a sparse tubercular ornament; and it is not marked by any well-defined groove for a slime-canal, though its upper half is impressed by a shallow fossa, which often appears in the fossils as if it were a vacuity in the bone, extending obliquely inwards and backwards from the antero-superior angle. The middle postorbital is not so deep as wide, and tapers a little forwards. The lower postorbital is much more elongated antero-posteriorly, truncated behind, pointed in front, and more closely tuberculated than either of the others.

The mandibular suspensorium is nearly vertical, so that the gape of the mouth is wide. As usual in the *Coelacanth*s, the hyomandibular, quadrate, and pterygoid bones are fused together on each side into a thin triangular plate, which articulates loosely in an elongated suture with the cranium. This articulation extends as far forwards as the front end of the parietal region, the anterior upper angle of the hyomandibular being considerably produced. The complete form of the plate can be determined from the specimens shown in Pl. XXXVII, figs. 1, 4. Its outer face (fig. 1, *ptq.*) is smooth, and the hyomandibular portion is strengthened by two vertical ridges which converge a little below. Its inner face (fig. 4) is densely covered with minute tubercular teeth, and the entopterygoid portion must have inclined inwards to form the roof of the mouth. The quadrate portion, which is completely shown from the inner face in fig. 4, is produced postero-inferiorly into a constricted prominence, which ends in a large ginglymoid condyle for articulation with the mandible. The anterior end of the pterygoid portion tapers to a thin edge, where it meets another lamina of bone, which bears relatively large conical teeth on its lower border, and may probably be interpreted as the palatine element. The maxilla (Pl. XXXV, fig. 10, *mx.*) occurs outside the lower border of the pterygoid plate, just beneath the suborbital. It is a narrow bar of bone, ornamented externally with a fine, close granulation, and bearing an irregular series of incurved conical teeth on its margin; but its complete shape and extent are unknown, and no specimen hitherto discovered exhibits a premaxilla. Of the mandible, each ramus is long and slender, deepest in its middle third, and specially remarkable for the large size of its inner space which would be occupied by the meckelian cartilage. It appears arched on account of the slight concavity of its lower margin and the rounded contour of its outer upper edge (see especially Pl. XXXVII, fig. 5). Its outer face is traversed below by a deep and wide longitudinal groove for the slime-canal. The angular bone (Pl. XXXV, fig. 9; Pl. XXXVII, figs. 5, 6, *ag.*) forms nearly two thirds of this face, rising to a considerable depth in its middle portion, but tapering to a point in front and to a somewhat more blunt ending behind. Its upper margin is gently curved, and its outer pitted or reticulated face is more or less sparsely tuberculated. The anterior end of the angular passes in an oblique suture below the posterior tapering extremity of the dentary, which completes the mandible in front. The latter bone (Pl. XXXV, fig. 9; Pl. XXXVII, figs. 5, 7, *d.*)

attains its greatest depth behind, where its sharp postero-superior angle is produced into a buttress against the splenial; it then rapidly contracts into its symphysial half, where it is thickened and curves inwards to meet its fellow in a moderately stout symphysis (Pl. XXXVII, fig. 7). The oral border of the dentary is rounded and toothless, and its outer face is smooth, except quite at the postero-inferior angle, where it is slightly tuberculated. Beneath it lies a partially-separate tuberculated scale of bone (Pl. XXXVII, fig. 7, *id.*), which is probably an infradentary reduced in size. Of the meckelian cartilage there are only two ossified remnants, one projecting behind the angular at the posterior extremity of the jaw (Pl. XXXVII, fig. 5, *x.*), the other forming a small articular element (fig. 6, *art.*), which is situated inside the upper margin of the angular just within its hinder half. The articular appears to be fused with the supporting angular bone, and does not exhibit its precise shape; but in an allied genus, *Mawsonia*, from the Lower Cretaceous of Brazil,¹ it is a separate element and seen to be merely a small nodule of bone, large enough to bear the facette for the ginglymoid articular end of the quadrate. The inner face of the mandible is formed by a thin, flat splenial plate, in which no sutures can be distinguished (Pl. XXXVII, figs. 1, 5, *spl.*). Its hinder portion corresponds in shape with the hinder half of the angular; its deepest portion in the middle third has a straight upper edge, while its anterior portion contracts forwards in the same manner as the dentary to which it is apposed. Its inner or oral face is covered with minute tubercular teeth, which become enlarged on the anterior region supported by the buttress of the dentary (just visible in Pl. XXXV, fig. 9). A separate coronoid bone is suturally united with the upper edge of the splenial, and is usually displaced in the fossils. It is irregularly triangular in shape, with the middle of its antero-superior edge thickened, indented, and projecting outwards (Pl. XXXV, fig. 10, *cor.*), while its inner face (Pl. XXXVII, fig. 8) is covered with minute tubercular teeth like those of the splenial.

Of the hyoid arch only two elements have been seen in the fossils. The stylohyal (Pl. XXXVII, fig. 1, *sty.*) is a long, laterally-compressed lamina of bone, truncated at each end, and slightly constricted in the middle. The ceratohyal, partly seen in Pl. XXXVIII, fig. 1 (*chy.*), is also laterally compressed, but scarcely expanded at the ends, and bearing on the middle of its lower edge a thin process of bone, which is about twice as wide as deep.

The branchial arches are conspicuous in many specimens, but their extremities have never been clearly observed. They appear to be in four pairs (Pl. XXXVIII, fig. 1, *br.*), each arch consisting of a single curved bone which is deeply grooved on its hinder face. They are united below by a large copula of the peculiar form which is always found in Cœlacanth fishes. Its smooth, expanded, bilobate, hinder end is well seen in Pl. XXXVII, fig. 9 (*cop.*). There are no traces of

¹ A. S. Woodward, Quart. Journ. Geol. Soc., vol. lxiii (1907), p. 136

gill-rakers or calcified gill-supports. Of the opercular apparatus, only the operculum itself appears to occur. Its shape and proportions are shown in Pl. XXXV, fig. 9 (*op.*), where it is only slightly crushed. Its point of suspension is conspicuous, and its upper and anterior bevelled margins are a little sinuous. Its inner face is smooth, without any strengthening ridges (B. M. no. 115), and its outer face is always closely ornamented with smooth rounded tubercles. The pair of gular plates (Pl. XXXVII, fig. 9, *gu.*) completely covers the space between the mandibular rami, and the contour of one is best seen in fig. 10. Each plate is ornamented, except in occasional smooth patches, with small rounded tubercles, which are very closely arranged, not in concentric lines.

In the axial skeleton of the trunk there are no traces of vertebral centra, but the arches are well ossified, and they are especially stout in the fin-bearing part of the tail. Each of the neural arches and each of the hæmals in the caudal region consist of a single piece, the two laminæ of the arch being firmly fused with the spine, which is inclined to them at a slight angle. The total number of segments is uncertain, but is approximately as shown in the restored skeleton, Text-fig. 49, p. 173. In the abdominal region the neural arches are remarkably short, but in the caudal region they gradually lengthen until the longest occurs beneath the first ray of the caudal fin, whence they rapidly decrease in size backwards. The hæmal arches in the caudal region are symmetrical with the opposed neurals, but those of the abdominal region must have been very small and short, none having hitherto been seen in the English Chalk fossils. Delicate short hæmals are shown in the hinder half of the abdominal region of a specimen of *M. speciosum* from the Turonian of Bohemia (B. M. no. P. 9007). There are no calcified vertebral arches in the short extension of the trunk beyond the insertion of the caudal fin, which is seen in Pl. XXXVI, fig. 3 (*t.*).

Immediately below the anterior half of the vertebral column, extending throughout the length of the body-cavity, the ossified air-bladder is always conspicuous (Pl. XXXVI, figs. 1, 2, *bl.*). It consists of large, round, or cycloid, thin laminæ, which are smooth on both faces, but sometimes exhibit a little crimping when crushed. These laminæ are deeply overlapping from behind forwards, or in a direction opposite to that of fish-scales; and they are in such loose contact that they are often displaced in the fossils. They are in three paired longitudinal series, each consisting of eighteen to twenty components. As described by W. C. Williamson (*loc. cit.*, 1849), they are composed of a pile of "horizontal lamellæ, between which are developed large lacunæ, identical with those found in the bones of the endoskeleton (Text-fig. 50). These lacunæ not only distribute their large canaliculi in the plane of the lamellæ, but shorter vertical twigs penetrate the lamellæ, and thus keep up a communication between the inner and outer surfaces of the bladder. Some of the external lamellæ lose their exact parallelism with those below, and one in particular assumes an

undulatory arrangement, in the folds of which, alternately above and below, are placed large irregularly-shaped lacunæ, the distorted prolongations from which are obviously modified canaliculi. This curious structure is covered over with other more dense and apparently structureless lamellæ, which fill up the irregularities and restore the parallelism of the surface with the lower lamellæ, constituting the exterior of the bladder. . . . No canals of any kind pass through the tissue." When well preserved, the air-bladder is seen to be largest in front, where it opens by a small median orifice (Pl. XXXVI, fig. 2, *o.*); and it gradually tapers backwards to a bluntly-pointed, closed hinder end.

In the pectoral arch the clavicle is much the largest element, and is not connected with any superficial, ornamented plate. It is long and narrow, gently arched; laterally compressed in its upper half, where it ends in a little rounded

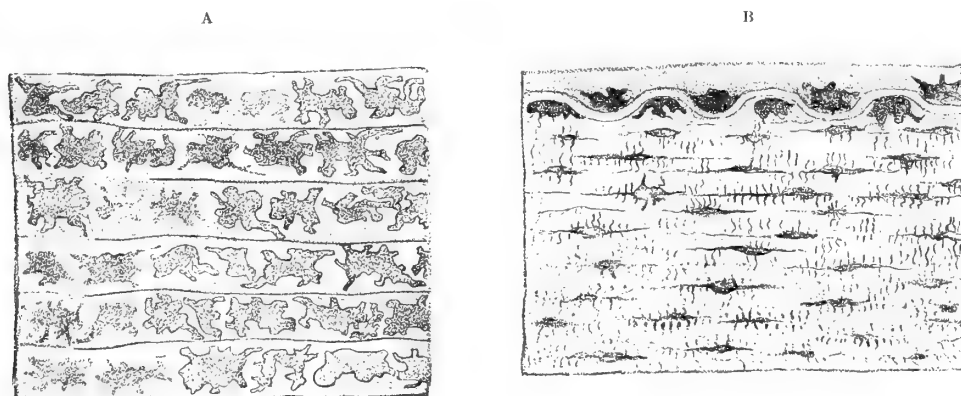


FIG. 50. *Macropoma mantelli*, Agassiz; microscopic structure of wall of air-bladder, magnified 350 diameters. A. Horizontal section of surface. B. Vertical section of complete thickness of wall. After W. C. Williamson.

expansion; and widened in its lower half, where it is convex in front, deeply hollowed behind (Pl. XXXV, fig. 9; Pl. XXXVII, fig. 9; Pl. XXXVIII, fig. 1, *cl.*), and ends in a point. Above and within the upper end of the clavicle is another large flattened plate, of which the complete form is shown in the type specimen (Pl. XXXVI, fig. 1, *ptt.*). It is also smooth, narrowest above and widest below, and specially remarkable for the slender, pointed process which is directed forwards from its middle. It may be interpreted either as supraclavicle or post-temporal, but agrees best in shape with the last-named bone in *Polypterus*. Below and in front of the lower end of the clavicle there is a small infraclavicle (Pl. XXXVII, fig. 9; Pl. XXXVIII, fig. 1, *icl.*), which is a long and slender bone with a smooth triangular expansion at its incurved lower end where it meets its fellow of the opposite side. Behind the middle of the clavicle and overlapped by it in one specimen (Pl. XXXVIII, fig. 2) there occurs a thin lamina of bone which may probably be named postclavicular (*pcl.*). It is longer than deep, deepest at each end, and slightly inclined upwards behind. Somewhat lower down, behind and within the expanded portion of the clavicle of other

specimens, there is apparently an ossified cartilage-bone of the scapular arch. This is somewhat crushed in the original of Pl. XXXVIII, fig. 1 (*sc.*), but it is seen to be hour-glass-shaped and slightly twisted on its longer axis. Part of its distal end is thicker in the original of Pl. XXXVII, fig. 9 (*sc.*), and in another fossil in the British Museum (no. P. 2051), where its widely-expanded proximal end is shown in contact with the concave face of the clavicle. The short rounded lobe of the pectoral fin does not exhibit any traces of the internal skeleton, but it is covered with small ornamented scales (*e.g.* in B. M. no. 4252). The pectoral lobe is fringed by about twenty fin-rays, in which the unjointed base is relatively long. The pelvic fin-supports (Pl. XXXVI, fig. 4) are a pair of triradiate bars, of which the longest arm is directed forwards and becomes slightly expanded distally. A gently curved narrow arm bends inwards to a somewhat crimped symphysis; while the outer arm forms a triangular expansion at the base of the lobate fin. Here again the endoskeletal elements which directly support the fringe of fin-rays are never preserved. As a whole the pelvic fin is somewhat smaller than the pectoral and comprises fewer rays. None of the rays in either of these fins are spinose or tuberculated.

Of the median fins the anterior dorsal, as usual in *Cœlacanth*s, comprises the stoutest rays, which do not surround a lobe but are directly supported by the straight edge of a plate of bone (Pl. XXXVI, figs. 1, 2, *do.*¹). The shape of this supporting plate is shown in the restoration, Text-fig. 49, p. 173, where its radiating strengthening ridges are also indicated. Of the eight fin-rays the first four are nearly equal in length, while the last four rapidly shorten backwards: in each ray the right and left halves are firmly fixed together, and a comparatively short distal portion is subdivided by distinct transverse joints. The front margin of each ray is provided with a double series of upwardly-pointing denticles which are loosely inserted in shallow pits: on the foremost ray there are also a few supplementary denticles. The posterior dorsal fin is lobate and comprises from fifteen to twenty slender rays, which have a relatively long unjointed base and are destitute of denticles (Pl. XXXVI, fig. 5). Its lobe is covered with thin, tuberculated scales, and does not exhibit any traces of its endoskeleton; but at its base there is always a well-ossified, forked support (Pl. XXXVI, figs. 1, 2, *do.*²). The anal fin, of which a fragment is preserved in the type specimen (*a.*), resembles the posterior dorsal and has a similarly-forked support, but it is slightly smaller and situated a little further back than the last-named fin. The caudal fin (Pl. XXXVI, figs. 1, 3, *c.*) comprises about twenty stout rays above and below the vertebral axis and forms a symmetrical termination of the fish. The actual end of the body is a slender, scaly lobe, which lies between the upper and lower halves of this fin, and tapers to a point without any fringing rays (Pl. XXXVI, fig. 3, *t.*). The caudal fin-rays scarcely diminish in length as they are traced backwards, and they are not expanded in their distal half where they are crossed

by distant joints. They are all provided with upturned, slender denticles fixed in shallow sockets on their anterior face. On the few foremost rays these denticles are more or less closely clustered (Pl. XXXVIII, fig. 3 *a*), but on the other rays they are in two regular series (fig. 3 *b*). At the base of the fin each ray tapers to a point and overlaps its own support, which is directly opposed to a corresponding neural or hæmal arch. About two free supports can sometimes be observed, both above and below, immediately in advance of the fin.

The scales are regularly arranged over the whole of the trunk, without enlargement or reduction in any region. They are thin, ovoid or cycloidal in shape, and deeply overlapping, and their inner surface is smooth, without ridge or boss (as proved by B.M. no. 49835). Their exposed portion is closely ornamented with elongated hollow tubercles or sharply pointed spinelets of ganoine, which are sometimes finely striated at their base. In the anterior half of the abdominal region the tubercles on the scales are nearly uniform in size and form a regular ornamentation (Pl. XXXVIII, fig. 4 *a*), but behind the anterior dorsal fin nearly all the flank-scales of the fish exhibit an enlargement of the two or three denticles which form the median longitudinal row (fig. 4 *b*), and these denticles are less depressed than the others, so that they are usually broken away in the fossils and represented only by their hollow bases of attachment. The scales of *Macropoma*, indeed, are very rarely intact owing to the prominence of the ornament, which becomes more or less torn away in fractured specimens. The lateral line is not marked in any way except between the lobes of the caudal fin, where the scales of the series evidently traversed by it are thickened in the curious manner shown in Pl. XXXVIII, fig. 5. In the hinder fork of the thickening on each scale may be seen the broken hollow base of an enlarged median denticle. The manner in which these scales are pierced by the slime-canal is not clear.

An elongated hard mass of cream-coloured phosphatic material is sometimes seen immediately above and behind the pelvic fins, and represents the infilled intestine of the fish. This body is round in section, with more or less rounded ends, and sometimes shows the mark of the spiral valve with which it was originally impressed. Similar coprolitic masses, of very fine and hard texture, are often found detached in the Chalk (Pl. XXXIX, figs. 1, 2), and some of them are so deeply marked by the spiral valve and wrinklins that they were at first mistaken for fossilised fir-cones.¹ They are commonly ascribed to *Macropoma*, and many of them are doubtless rightly so interpreted; but a large proportion of these coprolites are most likely referable to the Selachians and Chimæroids which abounded in the same sea.

Portions of very small skeletons of *Macropoma*, with bones having an appearance suggestive of immaturity, are sometimes met with in the English Chalk (Pl. XXXVIII, figs. 6, 7). So far as observable, the proportions of their head-

¹ G. A. Mantell, *Fossils of the South Downs* (1822), pp. 103, 158, 310, pl. ix, figs. 3, 7, 10.

bones resemble those of *M. mantelli*, but they exhibit scarcely any external ornament, and the operculum (*op.*) especially is remarkably smooth. They most probably represent the young of this species.

Horizons and Localities.—Turonian zones: neighbourhood of Lewes, Sussex. Zone of *Holaster subglobosus*: Burham and Halling, Kent; Dorking, Surrey. Zones of *Rhynchonella curvieri* to *Holaster planus*: Burham. Zone of *Marsupites*: Ovingdean, Brighton (C. D. Sherborn). Undetermined horizons near Guildford, Surrey, and at North Stoke, near Arundel, Sussex.

2. **Macropoma precursor**, sp. nov. Plate XXXVIII, figs. 8—10.

Type.—Imperfect head, etc.; British Museum.

Specific Characters.—Much smaller than the type species, with a relatively wider and shorter head. External head-bones marked with coarse reticulations, with little or no tubercular ornament; operculum smooth, with a few relatively large tubercles of ganoine in an occasional patch. Scales ornamented with elongated tubercles of ganoine, and no enlarged median series; all scales of lateral line thickened.

Description of Specimens.—This species is known only by fragmentary specimens of the head and trunk, representing a fish from 30 to 40 cm. in length. The type specimen exhibits the head from above (Pl. XXXVIII, fig. 8*a*) and in imperfect side-view (fig. 8), with remains of the air-bladder, dorsal fin, and scales. Other specimens display the trunk and part of the tail.

As seen in upper view (fig. 8*a*) the head is very distinctly wider than that of the type species, both in the parietal and the rostral regions; and the cranial roof exhibits only a coarse reticulation, with scarcely a trace of tubercles of ganoine. In side-view also (figs. 8, 9) the head appears relatively short, the arched sub-orbital (*so.*) being especially deep and stout, while the upper postorbital plate (*po.*¹) is much deeper than wide. The last-mentioned bones are coarsely reticulated like the cranial roof; but the large lower postorbital (displaced forwards in fig. 9, *po.*³) is reticulated only in its deep hinder half, smooth in its tapering anterior portion. The mandible agrees with that of the type species, except that it bears no tubercular ornament; and the dentary bone (fig. 9, *d.*) is clearly toothless.

The operculum (*op.*) is similar in shape to that of the type species, but is remarkably thin and smooth. It is ornamented only sparsely and in parts by relatively large tubercles (figs. 8*b*, 9*a*). The gular plate, as well seen in the type specimen, is marked only by a rather fine tuberculation.

All the scales hitherto observed, both in the abdominal and in the caudal regions, are ornamented only with elongated hollow tubercles which are nearly

uniform in diameter. Some of those at the base of the caudal fin are shown in fig. 10 *a*, while the thickened portion of a caudal scale of the lateral line is added in fig. 10 *b*. In these cases, as in others, it is evident that the median tubercles are not relatively large and prominent. A specimen obtained by Mr. G. E. Dibley from Burham shows that the lateral line is marked by the peculiarly thickened scales along the whole length of the trunk.

Horizon and Locality.—Zone of *Schloenbachia varians*: Folkestone and Dover, Kent. Zone of *Holaster subglobosus*: Burham, Kent (G. E. Dibley).

Subclass HOLOCEPILALI.

Order CHIMÆROIDEI.

Family CHIMÆRIDÆ.

The remains of Chimæroids hitherto discovered in the English Chalk are very fragmentary, but sufficient to show that they represent fishes closely similar to

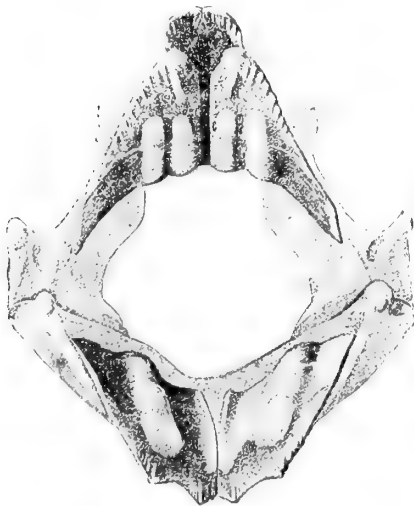


FIG. 51. *Chimæra phantasma*, Jordan and Fowler; opened jaws showing two pairs of upper dental plates and one pair of mandibular dental plates, nat. size.—Existing in Japanese seas. After B. Dean.

those now existing. They are all of extinct genera, and most of them belong to species much larger than any of modern times; but their dentition corresponds so well with that of the Chimæridæ (Text-fig. 51) that all the Cretaceous forms may be referred to this family.¹ The dental plates are stout, and certain areas, or "tritons," are specially hardened by the deposition of calcareous salts within and around groups of medullary canals, which rise to the functional surface. In the lower jaw there is a single pair of such plates, meeting at the symphysis. In the upper jaw there are two pairs, each meeting closely in the middle line. The anterior upper dental plates (commonly termed vomerine) are more or less cutting or prehensile; while the posterior upper dental plates (commonly termed palatine) have usually extensive tritoral areas for crushing.

Among existing species the shape of the dental plates is very variable (Text-fig. 52), so that in naming the fossils it is well to ignore small differences of proportions.

¹ B. Dean, "Chimæroid Fishes and their Development," Carnegie Inst. Publ., no. 32, 1906.

All the remains of English Cretaceous Chimæroids known in 1878 were exhaustively described and discussed by E. T. Newton, "The Chimæroid Fishes of the British Cretaceous Rocks" (Mon. IV in Mem. Geol. Surv., 1878). Since the publication of that work little has been added to our knowledge of the Cretaceous genera and species, and there is not much new in the following pages devoted to them.

The terms used in the description of the dental plates of Chimæroids are explained in Text-figs. 53—55, p. 184.

Genus **EDAPHODON**, Buckland.

Edaphodon, W. Buckland, Proc. Geol. Soc., vol. ii, 1838, p. 687;

Egerton, Quart. Journ. Geol. Soc., vol. iii, 1847, p. 351.

Passalodon, W. Buckland, *loc. cit.*, 1838, p. 687.

Psittacodon, L. Agassiz, Poiss. Foss., vol. iii, 1843, p. 340.

Eumylodus, J. Leidy, Extinct Vert. Fauna W. Territ. (Rep. U.S. Geol. Surv. Territ., vol. i, 1873), p. 309.

Generic Characters.—Mandibular dental plate massive, without any thickening on its outer face; its symphysial facette very broad; one anterior tritor present, and sometimes a smaller one below it; one median tritor, occasionally divided longitudinally, and two outer tritors. Palatine plate also very massive, without outer thickening; three tritors present, two being inner and one outer. Vomerine plate more or less triangular in side view, with tritors on the oral margin; post-oral region laterally expanded, without any thickening.

Type Species.—*Edaphodon bucklandi* (Agassiz, Poiss. Foss., vol. iii, 1843, p. 351, pl. xl d, figs. 1—4, 9—12, 19—24) from the Middle Eocene of Bracklesham Bay, Sussex.

Remarks.—This is a typically Cretaceous and Eocene genus, which does not seem to have become extinct until the dawn of the Miocene period. Three species are distinguishable by mandibular dental plates from the English Chalk.

1. **Edaphodon sedgwicki**, Agassiz. Plate XXXIX, fig. 3. Text-figures 53—55.

1843. *Chimæra* (*Psittacodon*) *sedgwickii*, L. Agassiz, Poiss. Foss., vol. iii, p. 349, pl. xl, figs. 17, 18.

1843. *Ischyodus sedgwicki*, P. de M. G. Egerton, Proc. Geol. Soc., vol. iv, p. 156.

1847. *Edaphodon sedgwicki*, P. de M. G. Egerton, Quart. Journ. Geol. Soc., vol. iii, p. 352.

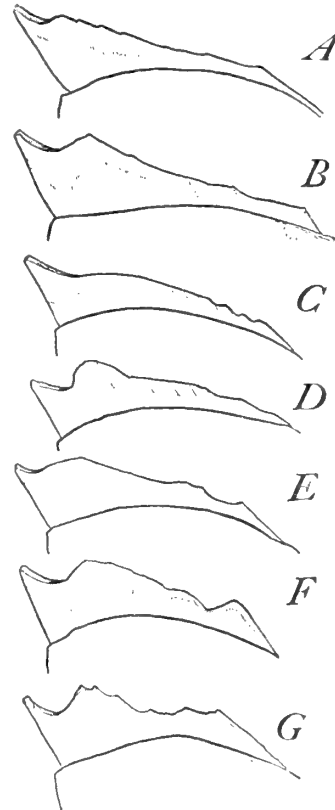


FIG. 52. *Chimæra colliei*, Bennett; outlines of mandibular dental plates in outer side view, nat. size, to show variations in shape in different individuals.—Existing in Pacific Ocean. After B. Dean.

1850. *Edaphodon sedgwicki*, F. Dixon, Geol. Sussex, p. 203.
 1864. *Edaphodon hualeyi*, H. G. Seeley, Ann. Mag. Nat. Hist. [3], vol. xiv, p. 276 [name only].
 1878. *Edaphodon sedgwickii*, E. T. Newton, Chimæroid Fishes Brit. Cret. Rocks (Mem. Geol. Surv., Mon. iv), p. 7, pls. i, ii.
 1891. *Edaphodon sedgwicki*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. ii, p. 73.

Type.—Imperfect right mandibular dental plate from the Cambridge Greensand; Geological Society of London.

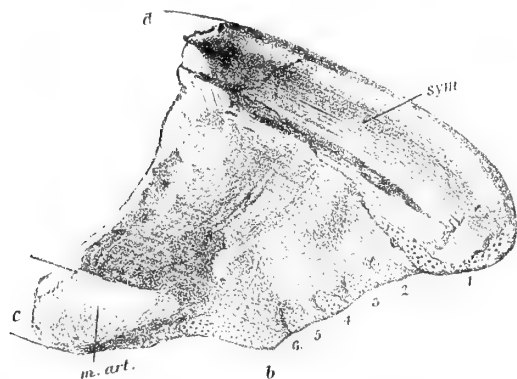


FIG. 53. *Edaphodon sedgwicki*, Agassiz; left vomerine dental plate, inner side view, two thirds nat. size.—Cambridge Greensand. *b*., posterior end of oral margin; *c*., *d*., post-oral margin; *m. art.*, surface articulating with palatine plate; *sym.*, symphysis; 1—6, tritons. After E. T. Newton.

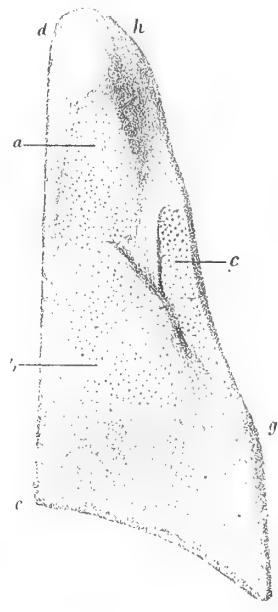


FIG. 54. *Edaphodon sedgwicki*, Agassiz; left palatine dental plate, oral view, two thirds nat. size.—Chalk, Lewes. *a*., *b*., anterior and posterior inner tritons; *c*., outer tritor; *d*., *e*., inner or symphyseal margin; *e*., *f*., posterior margin; *f*., *g*., post-oral margin; *g*., *h*., outer or oral margin. After E. T. Newton.

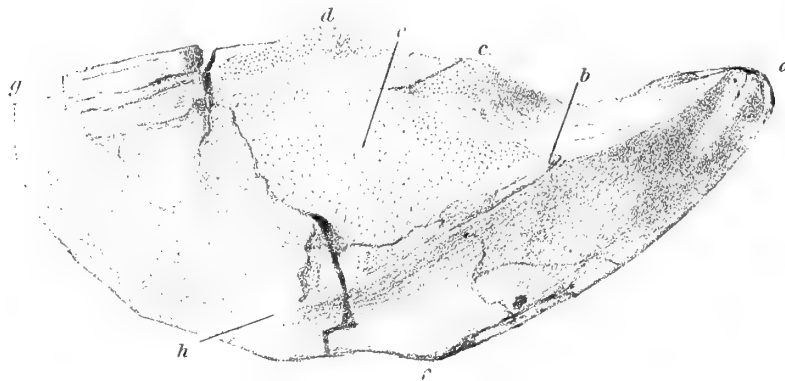


FIG. 55. *Edaphodon sedgwicki*, Agassiz; left mandibular dental plate, inner or oral view, two thirds nat. size.—Chalk, Lewes. *a*., beak with tritor; *b*., symphyseal tritor; *c*., *d*., anterior and posterior outer tritons; *e*., median tritor; *a*., *b*., *h*., *f*., symphyseal surface; *d*., *g*., post-oral margin. After E. T. Newton.

Specific Characters.—The largest species from the Chalk, the mandibular dental plate sometimes measuring 20 cm. in length. Mandibular plate with a very prominent beak, and the symphyseal facette occupying at least one third of

PLATE XXXIII.

FIGS.	PAGE.
1. <i>Protosphyraena minor</i> (Agassiz); greater part of rostrum, upper view, with (1 <i>a</i>) terminal portion in lower view, and (1 <i>b</i>) a cross-section, nat. size.—Zone of <i>Holaster subglobosus</i> ; Burham, Kent. B. M. no. 32337.	153.
2. Ditto; external ornament of rostrum, upper and (2 <i>a</i>) lower surfaces, three times nat. size.—Ibid. Mrs. Smith's Collection (B. M. no. 49100).	153.
3. <i>Protosphyraena stebbingi</i> , sp. nov.; portions of rostrum, the larger part in upper view, with (3 <i>a</i>) the terminal part in lower view, and (3 <i>b</i> , 3 <i>c</i>) two cross-sections, one half nat. size; also (3 <i>d</i>) portion of groove and ornament on upper surface, twice nat. size. The type specimen.—Same zone; Betchworth, Surrey. Collection of W. P. D. Stebbing, Esq., F.G.S.	153.
4. <i>Lophiostomus dixonii</i> , Egerton; remains of head and anterior portion of trunk, partly from above and the left side, partly (4 <i>a</i>) in right side view, partly (4 <i>b</i>) from below, and rostrum (4 <i>c</i>) in front view, nat. size; with portions of ornament of preoperculum (4 <i>d</i>) and gular plate (4 <i>e</i>), three times nat. size; also (4 <i>f</i>) inner view of scale, three halves nat. size. The type specimen.—Chalk; Alfriston, Sussex. B. M. no. 23023. <i>ao.</i> , antorbital; <i>br.</i> , branchiostegal rays; <i>ch.</i> , ceratohyal; <i>d.</i> , dentary; <i>fr.</i> , frontal; <i>gu.</i> , gular plate; <i>mx.</i> , maxilla; <i>na.</i> , nasal; <i>op.</i> , operculum; <i>p.</i> ¹ , <i>p.</i> ² , prominences; <i>pcl.</i> , postclavicular plate; <i>pct.</i> , base of pectoral fin; <i>plv.</i> , base of pelvic fin; <i>pmx.</i> , premaxilla; <i>pop.</i> , preoperculum; <i>sop.</i> , suboperculum.	155.
5. Ditto; scale, outer view, showing overlapped portion, three halves nat. size.—Ibid. Egerton Collection (B. M. no. P. 1116).	157.

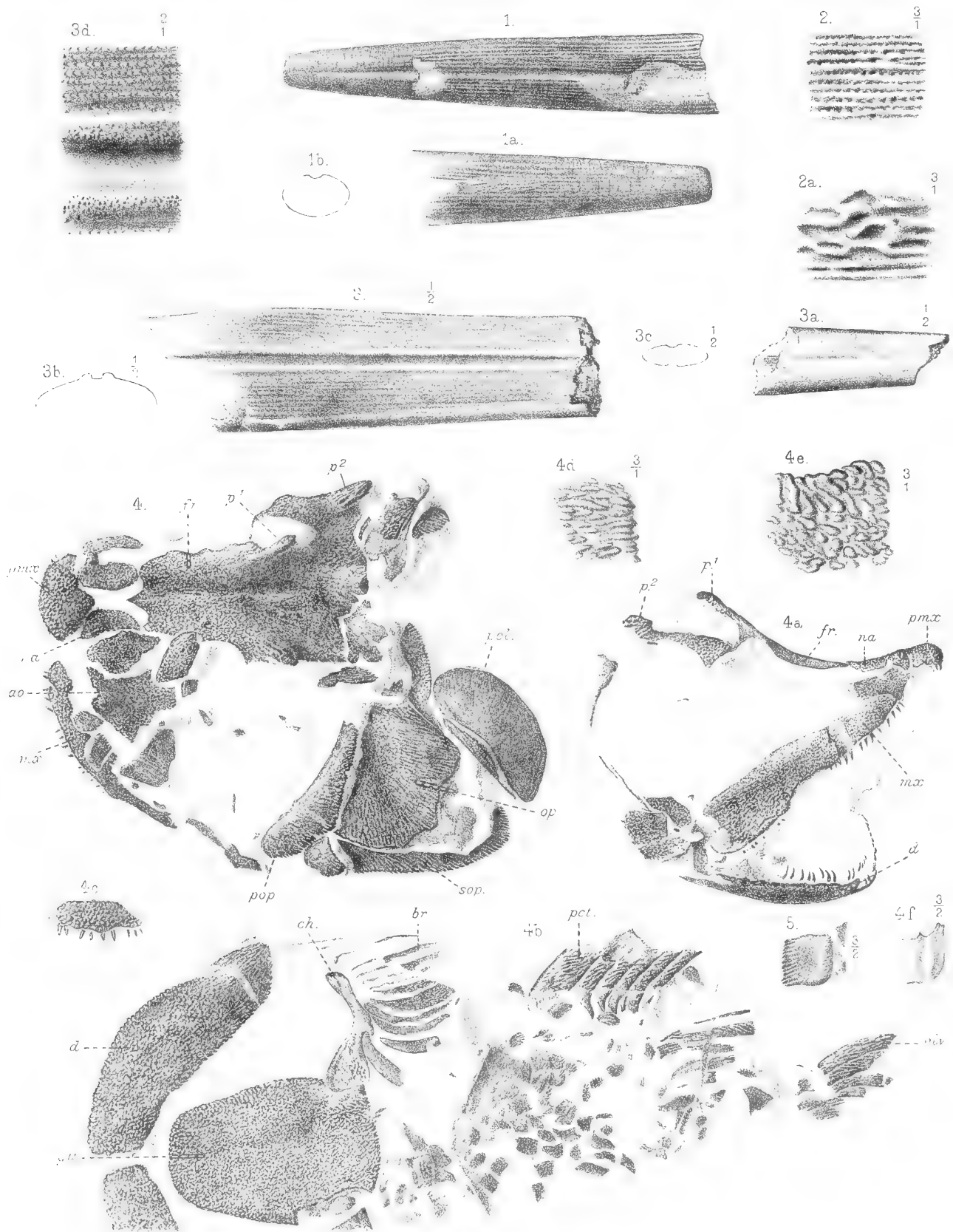
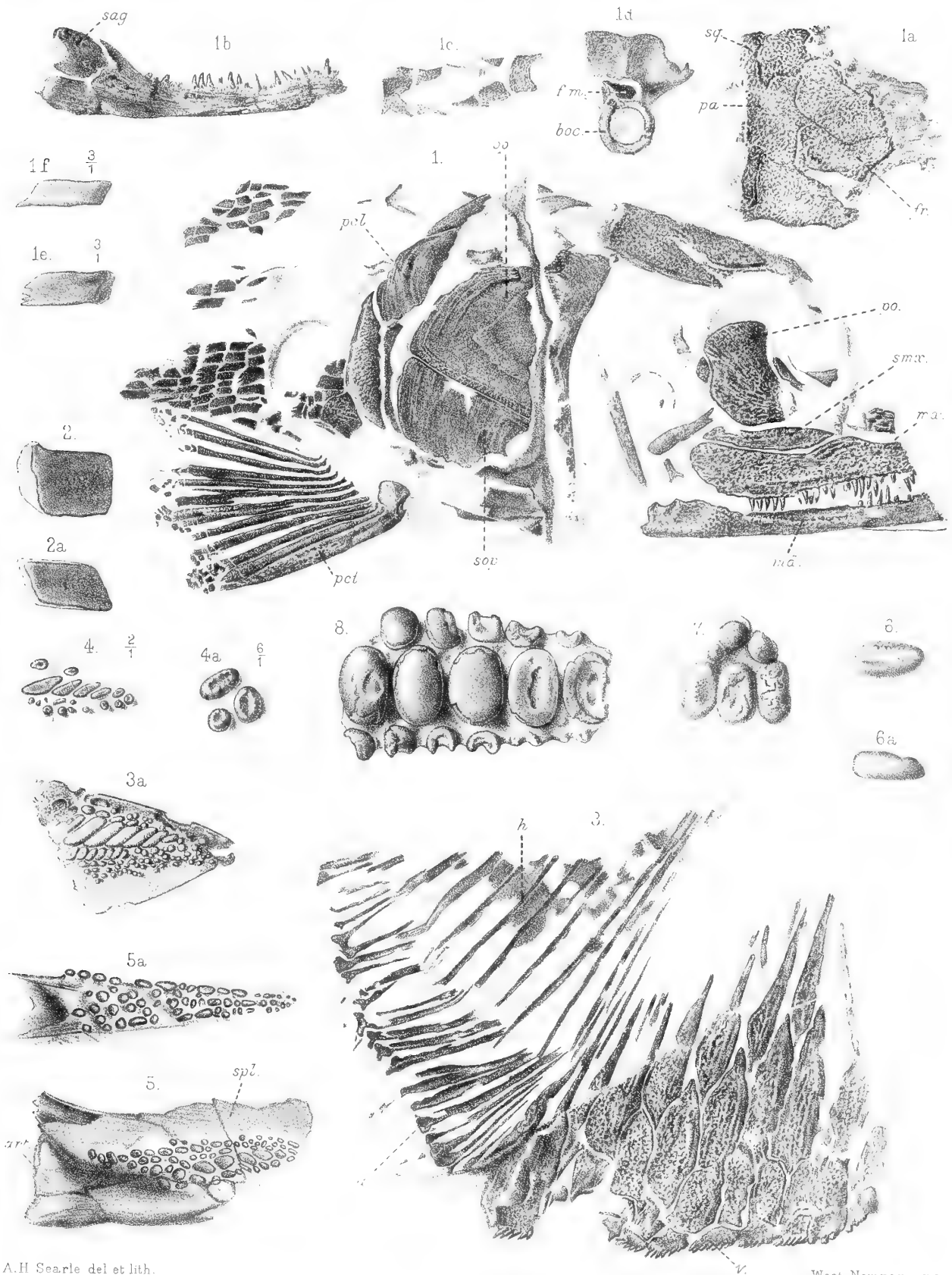


PLATE XXXIV.

FIG.	PAGE.
1. <i>Neorhombolepis excelsus</i> , A. S. Woodward; imperfect head and abdominal region, right side view, with (1 <i>a</i>) upper view of postorbital part of skull, (1 <i>b</i>) inner view of fractured mandibular ramus, (1 <i>c</i>) vertebral rings in section, and (1 <i>d</i>) hinder view of occiput, nat. size; also (1 <i>e</i> , 1 <i>f</i>) two scales, three times nat. size. The type specimen.—Zone of <i>Holaster subglobosus</i> ; Halling, Kent. B. M. no. 43077. <i>boc.</i> , basioccipital; <i>f. m.</i> , foramen magnum; <i>fr.</i> , frontal; <i>md.</i> , mandible; <i>mæ.</i> , maxilla; <i>op.</i> , operculum; <i>pa.</i> , parietal; <i>pcl.</i> , post-clavicle; <i>pct.</i> , pectoral fin; <i>po.</i> , postorbital; <i>sag.</i> , surangular; <i>smæ.</i> , supramaxilla; <i>sop.</i> , suboperculum; <i>sq.</i> , squamosal.	158.
2. <i>Neorhombolepis</i> (?) <i>punctatus</i> , A. S. Woodward; flank-scale and (2 <i>a</i>) associated narrower scale, nat. size.—Zone of <i>Holaster subglobosus</i> ; Blue Bell Hill, Burham, Kent. S. J. Hawkins Collection (B. M. no. P. 6526).	160.
3. <i>Anomæodus angustus</i> (Agassiz); lower half of trunk, right side view, and (3 <i>a</i>) right splenial bone with teeth, inner or oral view, nat. size.—Turonian zone; Houghton, Sussex. Dixon Collection (B. M. no. 25780). <i>a.</i> , series of supports for the anal fin, which is broken away; <i>h.</i> , hæmal spines with expansions; <i>v.</i> , ventral ridge-scales.	163.
4. Ditto; immature right splenial dentition, twice nat. size, with (4 <i>a</i>) three anterior teeth enlarged six times.—Zone of <i>Schloenbachia varians</i> ; Folkestone, Kent. Sedgwick Museum, Cambridge.	164.
5. <i>Anomæodus willetti</i> , A. S. Woodward; imperfect left mandibular ramus, inner or oral view, showing articular (<i>art.</i>) and splenial (<i>spl.</i>) bones; also (5 <i>a</i>) vomerine dentition, oral view, nat. size. The type specimen.—Zone of <i>Holaster subglobosus</i> ; Glynde, Sussex. Willett Collection no. 123, Brighton Museum.	164.
6. <i>Acrotemnus faba</i> , Agassiz; crown of tooth, upper view, and (6 <i>a</i>) in side view, nat. size. From the type specimen.—Chalk; Lewes. Mantell Collection (B. M. no. 4584).	169.
7. <i>Phacodus punctatus</i> , Dixon; group of teeth, oral view, nat. size. Type specimen.—Chalk; Lewes. Dixon Collection (B. M. no. 25829).	169.
8. Ditto; vomerine dentition, oral view, nat. size.—Chalk; Gravesend, Kent. Sedgwick Museum.	169.

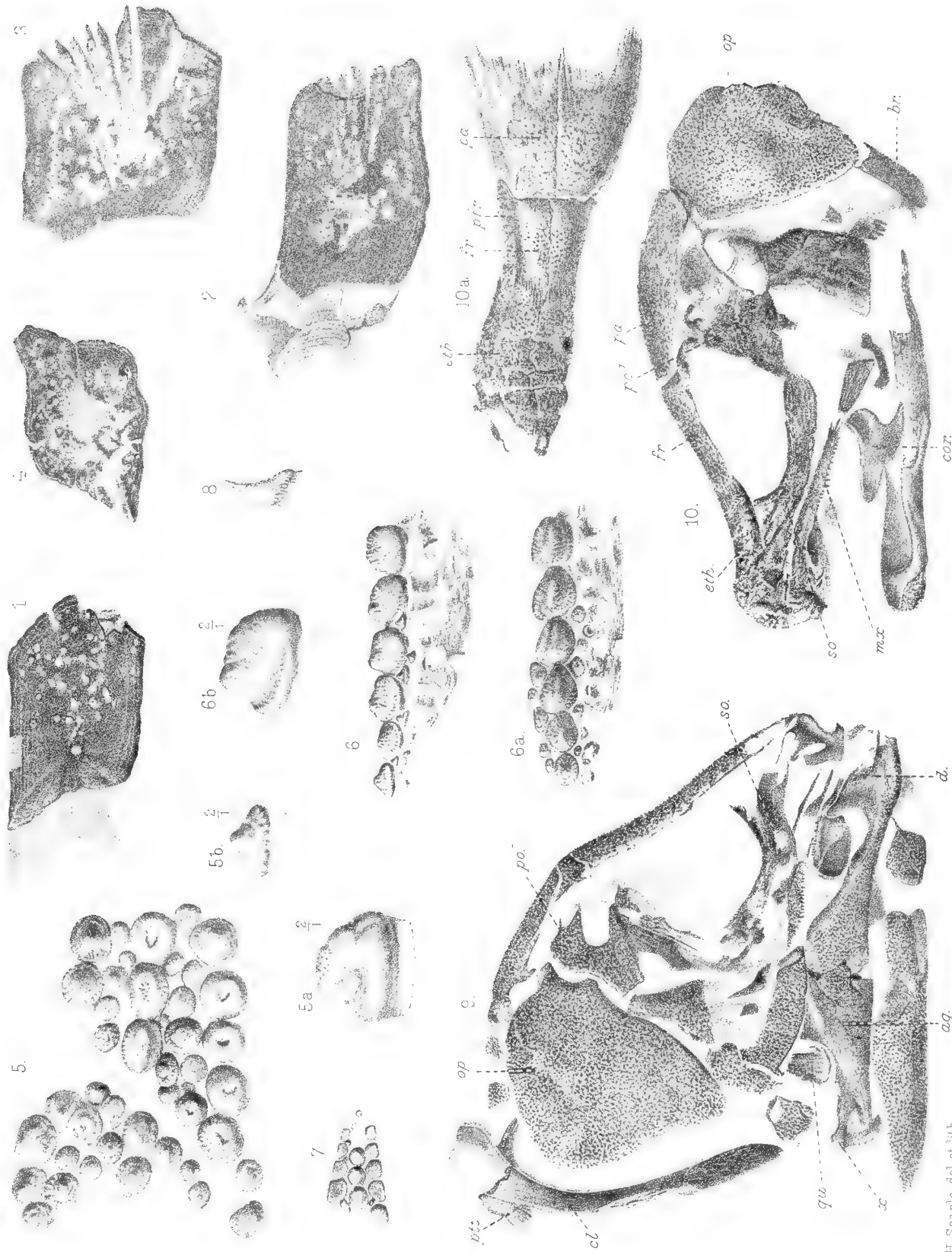


A. H. Searle del et lith.

West, Newman imp

PLATE XXXV.

FIGS.	PAGE.
1-4. <i>Lepidotus</i> (?) <i>pustulatus</i> , A. S. Woodward; four scales, the two first showing the overlapped portion, nat. size. The type specimen.—Zone of <i>Schloenbachia varians</i> ; Folkestone, Kent. B. M. no. P. 6201.	161.
5. <i>Gyrodus</i> (?) <i>cretaceus</i> , Agassiz; part of vomerine dentition, oral view, nat. size, with (5 <i>a</i>) one large tooth and (5 <i>b</i>) one small tooth in side view, twice nat. size.—Turonian zone; Lewes. Bowerbank Collection (B. M. no. 39048).	167.
6. Ditto; part of splenial dentition, the teeth shown in side and (6 <i>a</i>) oral views, nat. size, with (6 <i>b</i>) one large tooth in side view, twice nat. size.—Zone of <i>Terebratulina gracilis</i> ; Warlingham, Surrey. G. E. Dibley Collection (B. M. no. P. 6852).	168.
7. Ditto; part of vomerine dentition of young fish, oral view, nat. size.—Turonian zone; Southeram, Lewes. Capron Collection (B. M. no. 49804).	168.
8. Anterior prehensile tooth of a Pycnodont, side view, nat. size.—Chalk; Lewes. B. M. no. P. 7460.	169.
9. <i>Macropoma mantelli</i> , Agassiz; head, right side view, nat. size.—Turonian zone; Lewes. Capron Collection (B. M. no. 49834). <i>ag.</i> , angular; <i>cl.</i> , clavicle; <i>d.</i> , dentary, its upper process abutting against the toothed splenial; <i>op.</i> , operculum; <i>po.</i> ¹ , upper postorbital (the two lower postorbitals represented by fragments beneath); <i>ptl.</i> , post-temporal, overlapped by upper end of clavicle; <i>qu.</i> , articular end of quadrate; <i>so.</i> , suborbital; <i>x.</i> , ossified hinder end of meckelian cartilage.	174.
10. Ditto; head, left side view, and (10 <i>a</i>) upper view of cranium, nat. size.—Chalk; near Maidstone. Bowerbank Collection (B. M. no. 39070). <i>br.</i> , fragment of branchial arch; <i>cor.</i> , coronoid; <i>eth.</i> , dermal plates on ethmoidal region; <i>fr.</i> , frontal; <i>mx.</i> , maxilla; <i>pa.</i> , parietal; <i>pfr.</i> , parafrontals; other letters as in fig. 9.	174.



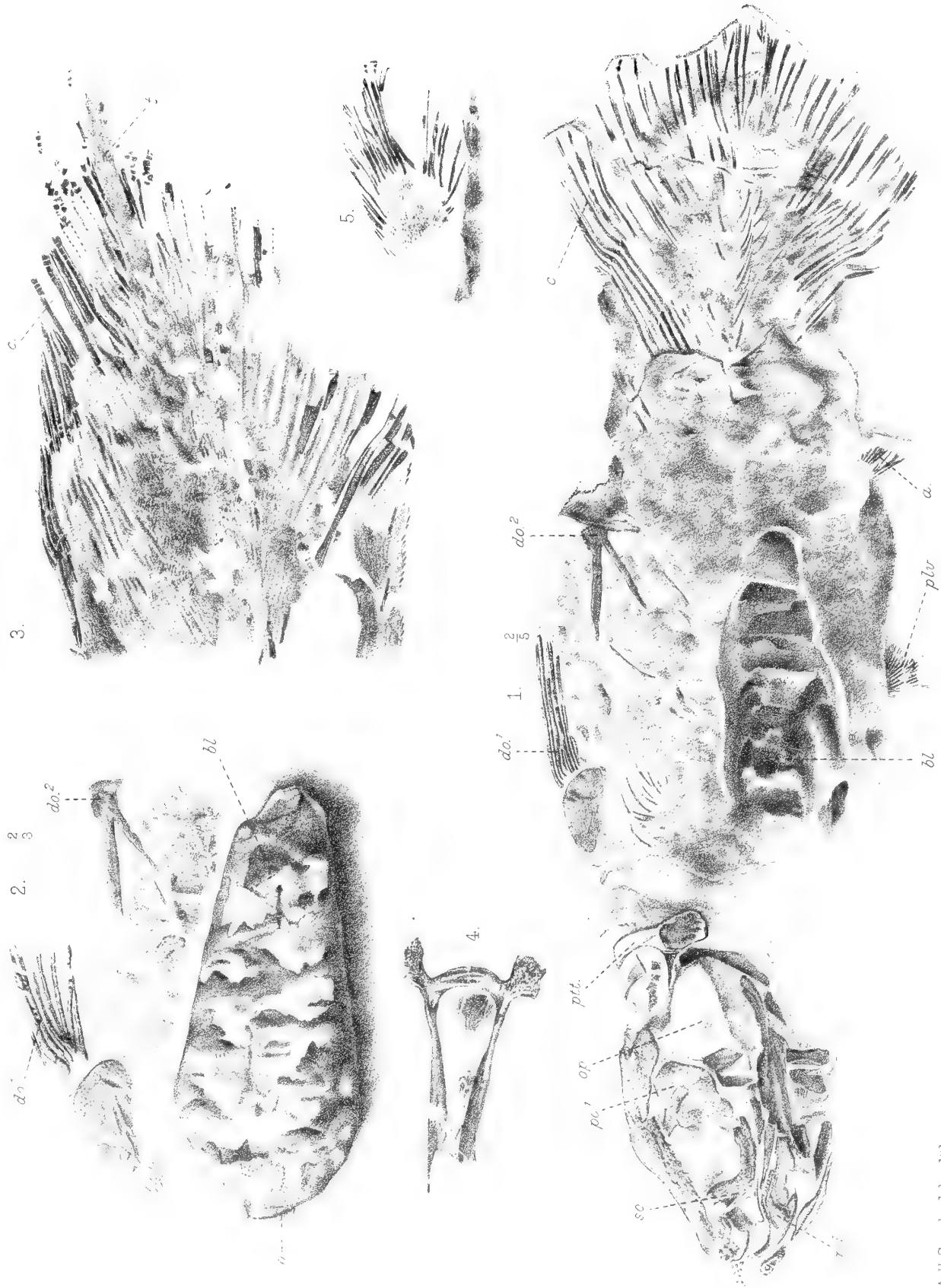
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1-4. *Lepidotus*. 5-8. *Pycnodonts*. 9, 10. *Macropoma*

PLATE XXXVI.

FIG.		PAGE.
1.	<i>Macropoma mantelli</i> , Agassiz; imperfect fish, left side view, two-fifths nat. size. The type specimen.—Turonian zone; Lewes. Mantell Collection (B. M. no. 4219). <i>a.</i> , rays of anal fin; <i>bl.</i> , air-bladder; <i>c.</i> , caudal fin; <i>do.</i> ¹ , <i>do.</i> ² , remains of two dorsal fins and their supports; <i>md.</i> , mandible; <i>op.</i> , operculum; <i>plv.</i> , rays of pelvic fins; <i>po.</i> ¹ , upper postorbital; <i>ptt.</i> , post-temporal; <i>so.</i> , suborbital.	172.
2.	Ditto; portion of abdominal region, left side view, showing the air-bladder (<i>bl.</i>) incomplete behind but perfect at its anterior orifice (<i>o.</i>), also remains of dorsal fins (<i>do.</i> ¹ , <i>do.</i> ²), two-thirds nat. size.—Ibid. Mantell Collection (B. M. no. 4260).	177.
3.	Ditto; tail showing caudal fin (<i>c.</i>) and scaly terminal caudal lobe (<i>t.</i>), nat. size.—Ibid. Mantell Collection (B. M. no. 4236).	177.
4.	Ditto; pair of pelvic bones, nat. size.—Ibid. Mantell Collection (B. M. no. 4256).	179.
5.	Ditto; posterior dorsal fin showing scaly lobe, nat. size.—Ibid. B. M. no. P. 7654.	179.

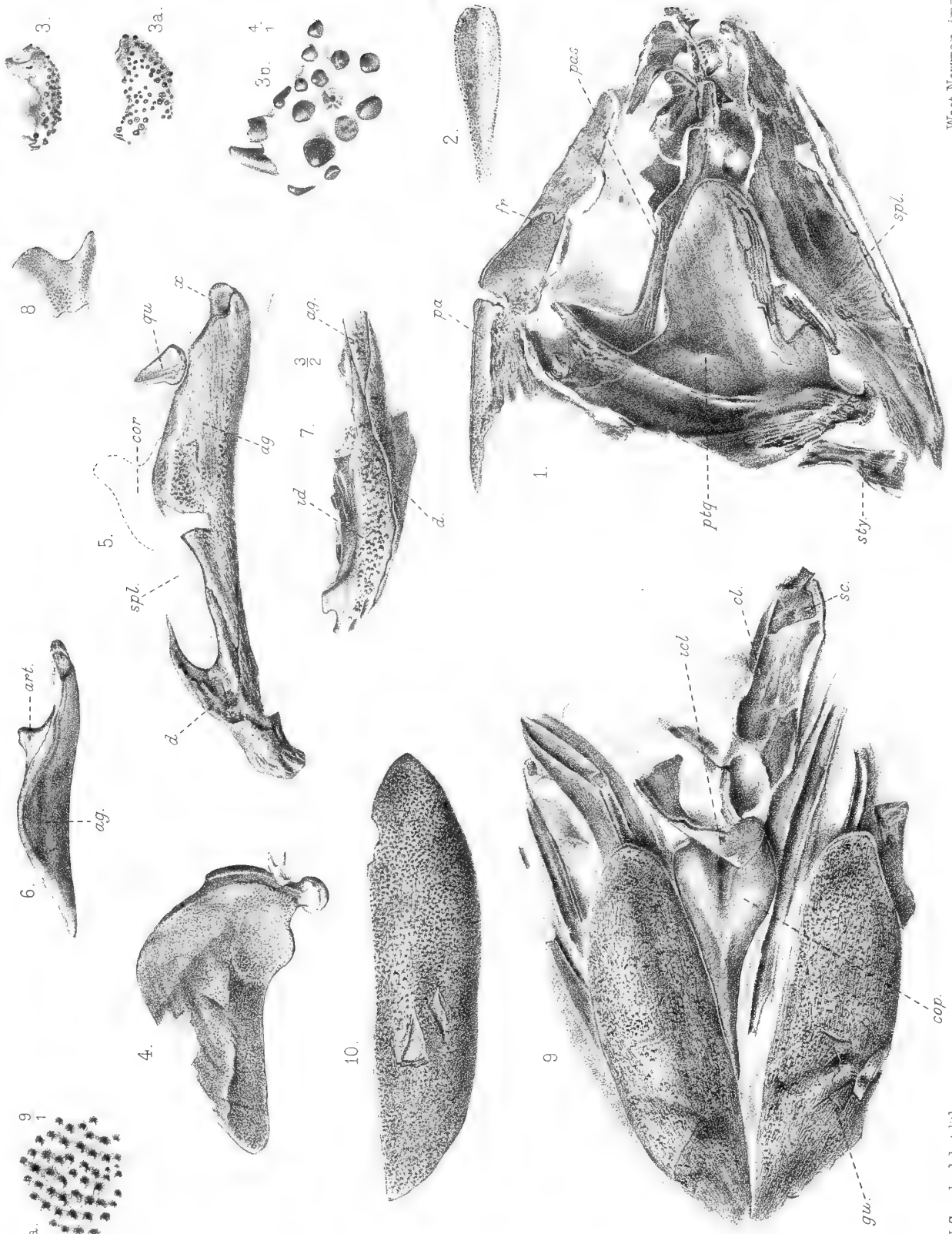


West, Newman imp.

Macropoma.

PLATE XXXVII.

FIG.	PAGE.
1. <i>Macropoma mantelli</i> , Agassiz; head with outer bones removed, right side view, nat. size.—Turonian zone; Lewes. Mantell Collection (B. M. no. 4237). <i>fr.</i> , frontal; <i>pa.</i> , parietal; <i>pas.</i> , parasphenoid; <i>ptq.</i> , pterygoquadrate; <i>spl.</i> , splenial; <i>sty.</i> , stylohyal.	175.
2. Ditto; spatulate anterior end of parasphenoid, oral view, nat. size.—Ibid. Enniskillen Collection (B. M. no. P. 3352).	174.
3. Ditto; supposed vomer, posterior and (3 <i>a</i>) oral views, nat. size, with (3 <i>b</i>) some teeth four times nat. size.—Ibid. Mantell Collection (B. M. no. 4270).	174.
4. Ditto; right pterygoquadrate, inner or oral view, nat. size, with (4 <i>a</i>) some teeth nine times nat. size.—Ibid. Mantell Collection (B. M. no. 4246).	175.
5. Ditto; left mandibular ramus, outer and slightly lower view, nat. size.—Chalk; Kent. Mrs. Smith's Collection (B. M. no. 49094). <i>ag.</i> , angular; <i>cor.</i> , outline of coronoid; <i>d.</i> , dentary; <i>qu.</i> , articular end of quadrate; <i>spl.</i> , cavity closed inside by splenial; <i>x.</i> , hinder end of ossified meckelian cartilage.	175.
6. Ditto; left angular bone (<i>ag.</i>) of mandible, outer view, showing articular (<i>art.</i>) within, nat. size.—English Chalk. Beckles Collection (B. M. no. P. 6454).	175.
7. Ditto; symphysial end of right mandibular ramus, lower view, showing infradentary plate (<i>id.</i>) below the dentary (<i>d.</i>) and angular (<i>ag.</i>), three halves nat. size.—Turonian zone; Whorne's Place, Rochester. B. M. no. 43851.	176.
8. Ditto; right coronoid, inner or oral view, nat. size.—Turonian zone; Lewes. Mantell Collection (B. M. no. 4246).	176.
9. Ditto; lower view of head and pectoral arch, nat. size.—English Chalk. Beckles Collection (B. M. no. P. 6455). <i>cl.</i> , clavicle; <i>cop.</i> , copula; <i>gu.</i> , gular plate; <i>icl.</i> , infraclavicle; <i>sc.</i> , scapular arch.	177.
10. Ditto; right gular plate, lower view, nat. size.—English Chalk. Enniskillen Collection (B. M. no. P. 4548).	177.



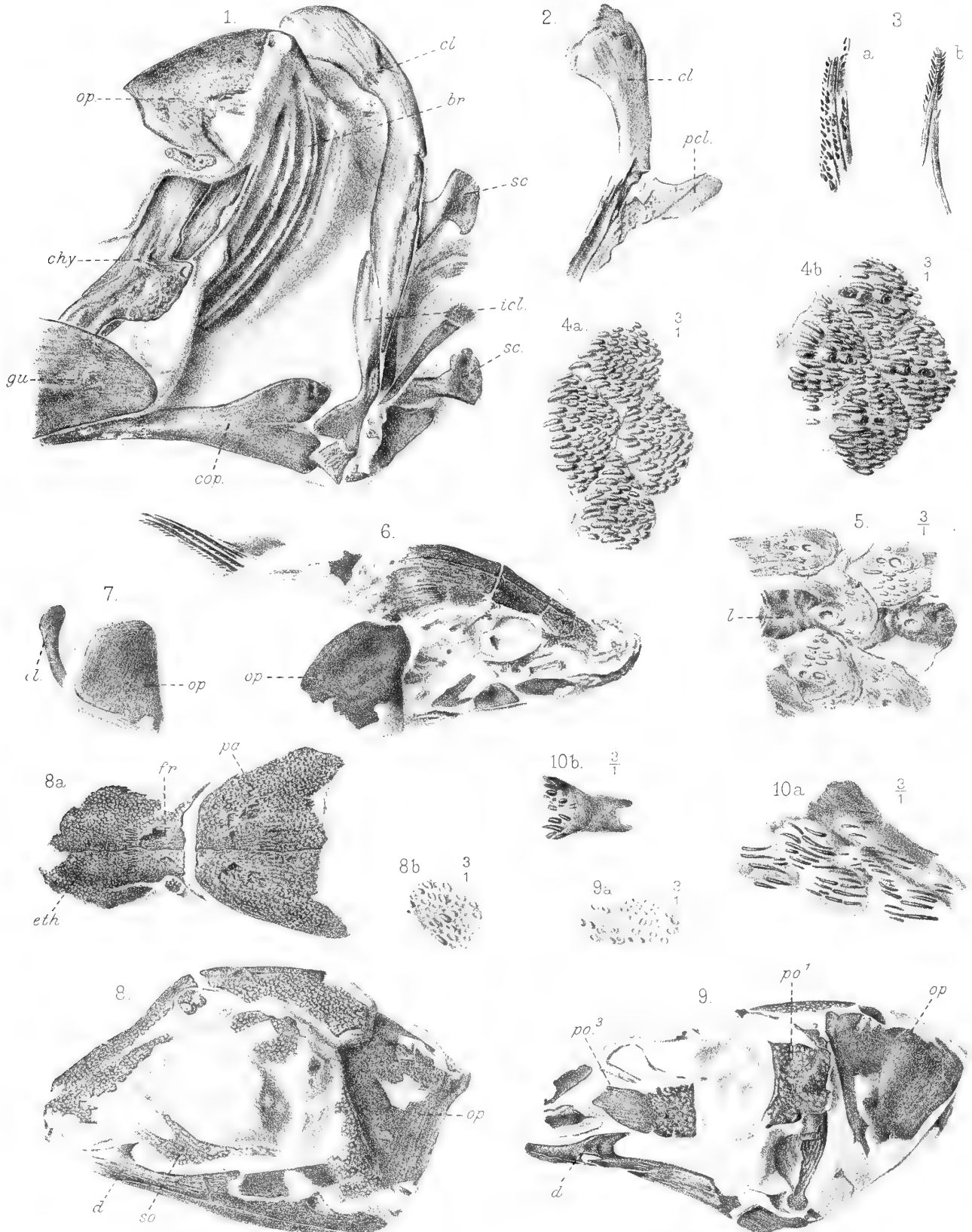
A. H. Searle del et lith.

Macropoma.

West Newman imp.

PLATE XXXVIII.

FIG.	PAGE.
1. <i>Macropoma mantelli</i> , Agassiz; left pectoral arch, branchial arches, and adjacent bones, nat. size.—Chalk; near Maidstone. Enniskillen Collection (B. M. no. P. 4547). <i>br.</i> , branchial arches; <i>chy.</i> , ceratohyal; <i>cl.</i> , clavicle; <i>cop.</i> , copula; <i>gu.</i> , hinder end of gular plate; <i>icl.</i> , infraclavicle; <i>op.</i> , operculum; <i>sc.</i> , scapular arch.	178.
2. Ditto; upper part of left clavicle (<i>cl.</i>) and postclavicle (<i>pcl.</i>), nat. size.—Turonian zone; Lewes. Mantell Collection (B. M. no. 4270).	178.
3. Ditto; fin-rays in side view from front (<i>a</i>) and in anterior view from hinder part (<i>b</i>) of caudal fin, showing denticles, nat. size.—Chalk, Kent. Mrs. Smith's Collection (B. M. no. 49096).	180.
4. Ditto; scales from anterior (<i>a</i>) and posterior (<i>b</i>) abdominal region, three times nat. size.—Turonian zone; Lewes. Mantell Collection (B. M. no. 4269). The large spinous tubercles in cross-section.	180.
5. Ditto; caudal scales, showing thickening for lateral line (<i>l.</i>) and hollow base of large median spinous tubercle, three times nat. size.—Chalk; Guildford. Capron Collection (B. M. no. 49832).	180.
6. Ditto; head and adjacent parts of young individual showing smooth operculum (<i>op.</i>), nat. size.—Zone of <i>Holaster subglobosus</i> ; Dorking, Surrey. Capron Collection (B. M. no. 49837).	181.
7. Ditto; small smooth operculum (<i>op.</i>) and upper end of clavicle (<i>cl.</i>), nat. size.—Zone of <i>Holaster subglobosus</i> ; Glynde, Sussex. Capron Collection (B. M. no. P. 10755).	181.
8. <i>Macropoma precursor</i> , sp. nov.; left side view of head, with (8 <i>a</i>) upper view of cranial roof, nat. size, and (8 <i>b</i>) tubercular ornament of operculum, three times nat. size. The type specimen.—Zone of <i>Schloenbachia varians</i> ; Folkestone, Kent. B. M. no. 35700. <i>d.</i> , dentary; <i>eth.</i> , ethmoidal dermal plates; <i>fr.</i> , frontal; <i>op.</i> , operculum; <i>pa.</i> , parietal; <i>so.</i> , suborbital.	181.
9. Ditto; left side view of head, nat. size, with (9 <i>a</i>) tubercular ornament of operculum, three times nat. size.—Ibid. Beckles Collection (B. M. no. P. 6453). <i>po.</i> ¹ , <i>po.</i> ³ , upper and lower post-orbital plates, displaced; other letters as in fig. 8.	181.
10. Ditto; scales from the caudal region (<i>a.</i>) and thickening of a scale from the lateral line of the same region (<i>b.</i>), three times nat size.—Ibid. Gardner Collection (B. M. no. 47239).	182.



Palæontographical Society, 1909.

A MONOGRAPH

OF THE

CRETACEOUS LAMELLIBRANCHIA

OF

ENGLAND.

BY

HENRY WOODS, M.A.

UNIVERSITY LECTURER IN PALÆOZOOLOGY, CAMBRIDGE.

VOL. II. PART VI.

SOLENIIDÆ, SAXICAVIIDÆ, PHOLADIIDÆ, TEREDINIIDÆ, ANATINIIDÆ,
PHOLADOMYIIDÆ, PLEUROMYIIDÆ, POROMYACIIDÆ, AND
CUSPIDARIIIDÆ.

PAGES 217—260; PLATES XXXV—XLIV.

LONDON:

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1909.

PRINTED BY ADLARD AND SON, LONDON AND DORKING.

Family—SOLENIDÆ, *Lamarck*.

Genus—PHARUS, *Leach* in *J. E. Gray*, 1847.

(‘*Synops. Brit. Mus.*,’ ed. 42, 1840, p. 154; ‘*Ann. Mag. Nat. Hist.*,’ vol. xx, 1847, p. 272;
and ‘*Proc. Zool. Soc.*,’ 1847, p. 189.)

PHARUS WARBURTONI (*Forbes*), 1845. Plate XXXV, figs. 1—3.

1845.	SOLECURTUS WARBURTONI,	<i>E. Forbes</i> .	<i>Quart. Journ. Geol. Soc.</i> , vol. i, p. 237, pl. ii, fig. 1.
1850.	—	—	<i>A. d'Orbigny</i> . <i>Prodr. de Pal.</i> , vol. ii, p. 117.
1854.	—	—	<i>J. Morris</i> . <i>Cat. Brit. Foss.</i> , ed. 2, p. 224.
1864.	—	—	<i>F. J. Pictet and G. Campiche</i> . <i>Foss. Terr.</i> <i>Crét. Ste. Croix (Matér. Pal.</i> <i>Suisse, ser. 4), p. 30.</i>
1870.	—	—	<i>F. Stoliczka</i> . <i>Palæont. Indica, Cret. Fauna S.</i> <i>India, vol. iii, p. 99.</i>

Description.—Shell elongate-oblong, compressed, slightly inequilateral, gaping at the ends, the posterior higher than the anterior part. Dorsal margin almost straight. Ventral margin slightly flexuous, and slightly oblique to the dorsal margin. Anterior margin rounded. Posterior margin slightly truncate, rounded. Umbones small, inconspicuous, sub-median. Ornamentation consists of growth-rings, and on the anterior part of the shell, of numerous, very small, rather irregular, radial ribs.

Measurements :

	(1)	(2)	(3)	(4)
Length .	67	60·5	55	44 mm.
Height .	17	16	15	12 „

(1—4) Crackers, Atherfield.

Affinities.—This species, as was pointed out by Stoliczka, closely resembles in form living examples of the genus *Pharus*; but the hinge appears to be unknown, for although the species is well represented in collections, and the specimens are in an excellent state of preservation, none of them shows the interior of the shell. A single valve resembling *P. Warburtoni*, but relatively higher, has been described by Dr. Kitchin¹ from the Uitenhage Series. Dr. Harbort² states that his *Solecurtus longovatus* is similar to our species, but is relatively higher and shorter.

¹ ‘*Ann. S. African Mus.*,’ vol. vii (1908), p. 155, fig. 1.

² ‘*Die Fauna d. Schaumburg-Lippe’schen Kreidemulde*’ (1905), p. 71, pl. viii, fig. 6. An imperfect internal cast found in the Upper Greensand of Devizes shows some resemblance to this species.

Type.—From Atherfield, in the Museum of the Geological Society.

Distribution.—Lower Greensand (Crackers) of Atherfield. Atherfield Beds of East Shalford and Sevenoaks. Sandgate Beds of Parham Park.

Genus—SOLECURTUS, *H. M. D. de Blainville*, 1824.

(‘*Dict. Sci. nat.*,’ vol. xxxii, p. 351.)

Sub-genus—AZOR, *W. E. Leach*, 1847.

(In *Gray*, ‘*Ann. Mag. Nat. Hist.*,’ vol. xx, p. 272; and ‘*Proc. Zool. Soc.*,’ 1847, p. 189.)

SOLECURTUS (AZOR?) PELAGI, *d’Orbigny*, 1850. Plate XXXV, fig. 4.

1850. SOLECURTUS PELAGI, *A. d’Orbigny*. *Prodr. de Pal.*, vol. ii, p. 158.

1867. — — — *E. Guéranger*. *Album Paléont. de la Sarthe*, p. 12,
pl. xv, fig. 6.

1870. — — — *F. Stoliczka*. *Palæont. Indica, Cret. Fauna S. India*,
vol. iii, p. 99.

Description.—Shell elongate, considerably inequilateral, moderately convex, but slightly concave at the middle of the sides. Postero-dorsal area flattened or slightly concave, limited by an indistinct carina. Antero-dorsal margin curved; anterior margin rounded; postero-dorsal margin straight, nearly parallel to the ventral margin; posterior margin curved, slightly oblique. Ornamentation consists of small concentric ribs near the umbo, and of growth-rings elsewhere. Length 30 mm.; height 12 mm.

Affinities.—The identification of the English specimens with d’Orbigny’s species is not quite free from doubt, since only two valves, both somewhat imperfect, have yet been seen. In the specimen figured by Guéranger the postero-dorsal area seems relatively higher than in our specimens; also the postero-dorsal margin is less nearly straight, but this difference may be due to imperfect preservation.

S. Pelagi seems to be closely allied to *S. Guérangeri*, d’Orbigny,¹ but the carina is less distinct, and the postero-ventral angle appears to be more rounded.

Until specimens showing the hinge satisfactorily have been found, the generic position of this species must be regarded as doubtful.

Type.—From the Cenomanian of Le Mans.

Distribution.—Upper Greensand (zone of *Schlarnbachia rostrata*) of Blackdown.

¹ ‘*Pal. Franç. Terr. Crét.*,’ vol. iii (1845), p. 321, pl. cccli, figs. 1, 2. Guéranger, ‘*Album Paléont. de la Sarthe*’ (1867), p. 12, pl. xv, fig. 4. An internal cast of a left valve from the Upper Greensand of Warminster resembles *S. Guérangeri*.

1850.	SOLECURTUS	ACTEON, <i>A. d'Orbigny.</i>	Prodr. de Pal., vol. ii, p. 158.
1867.	—	— <i>E. Guéranger.</i>	Album Paléont. de la Sarthe, p. 12, pl. xv, figs. 1, 2.
1870.	—	— <i>F. Stoliczka.</i>	Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 99.

Measurements (approximate):

			(1)		(2)
Length	.	.	46	.	20 mm.
Height	.	.	24	.	10 „

Affinities.—Only two specimens have been seen; they resemble closely Guéranger's figures of *S. Acteon*. The hinge is unknown, so that the generic position cannot be determined at present.

Distribution.—Upper Greensand (zone of *Schlaenbachia rostrata*) of Haldon. Cenomanian (Meyer's Bed 10) of Dunscombe, South Devon.¹

(‘Amer. Journ. Conch.,’ vol. iii, pp. 15, 188 ; F. B. Meek, ‘Invert. Cret. and Tert. Foss. U. Missouri,’ 1876, p. 252.)

1845. SOLEN DUPINIANUS, *A. d'Orbigny*. Pal. Franç. Terr. Crét., vol. iii, p. 320,
pl. cccl, figs. 3, 4.
1850. — — *A. d'Orbigny*. Prodr. de Pal., vol. ii, p. 135.

¹ An internal cast from the Cenomanian (Bed 11) of Dunscombe, South Devon, resembles *Solecirtus æqualis*, d'Orbigny, but is not sufficiently well-preserved for identification. *S. æqualis* has been referred doubtfully to the genus *Pharella* by Stoliczka and by Meek, whilst de Loriol regards it as belonging to *Siliquaria* (= *Tagulus*). See d'Orbigny, 'Pal. Franç. Terr. Crét.,' vol. iii (1845), p. 321, pl. cccl, figs. 5—7, and 'Prodr. de Pal.,' vol. ii (1850), p. 158; Guéranger, 'Album Paléont. de la Sarthe' (1867), p. 12, pl. xv, fig. 3.

1864. SOLEN DUPINIANUS, *F. J. Pictet and G. Campiche*. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 29.
1897. — — — *R. B. Newton*. Proc. Dorset Nat. Hist. and Antiq. Field Club, vol. xviii, p. 93.

Description.—Shell elongate, more or less oblong, slightly convex, compressed near the antero-dorsal margin, considerably inequilateral. Dorsal margin nearly straight. Anterior end rounded, not so high as the posterior part of the shell. Ventral margin nearly straight and nearly parallel to the dorsal margin, curving upwards anteriorly. Posterior margin convex, forming a rounded angle with the ventral margin. Umbones small, inconspicuous, situated at less than a third of the length of the shell from the anterior margin.

Ornamentation consists of small concentric ridges; in some cases the ridges cut the posterior part of the ventral margin obliquely. A strong internal rib extends from the umbo ventrally, but does not reach the ventral margin.

Measurements:

	(1)	(2)	(3)
Length . . .	31	29	26 mm.
Height . . .	10	10	9 „

(1—3) Gault, Black Ven.

Affinities.—The occurrence of this species in the Gault of England has been recorded by De Rance and R. B. Newton—by the former from Black Ven, and by the latter from Okeford Fitzpaine. Although the example figured by d'Orbigny is imperfect, consisting of the posterior part of a left valve only, yet the English specimens agree sufficiently closely with d'Orbigny's figure to make it probable that they have been correctly identified with *L. Dupinianus*. In most of the English examples, however, the posterior margin is more convex and the postero-dorsal angle more rounded than in d'Orbigny's figure; but in a few specimens, which have been slightly crushed, these differences are not noticeable.

The species which resemble *L. Dupinianus* are *L. concentristriatus* (Müller¹), *L. Petersi* (Reuss²), *L. truncatula* (Reuss³), *L. Moreana* (d'Orbigny⁴) and *L. limata* (Stoliczka⁵).

Type.—From the Albion of Ervy (Aube).

Distribution.—Lower Gault of Black Ven and Okeford Fitzpaine. Upper Greensand of Devizes. Recorded by Jukes-Browne from the Gault of the Isle of Wight.

¹ 'Jahrb. d. k. preussisch. geol. Landesanst. für 1887' (1888), p. 431, pl. xviii, fig. 5.

² 'Kreideschicht. i. d. Ostalpen' (1854), p. 145, pl. xxviii, fig. 10. Zittel, 'Die Bivalv. d. Gosaugeb.,' I (1865), p. 5 [109], pl. i, fig. 3.

³ 'Die Verstein. der böhm. Kreideformat.,' pt. 2 (1846), p. 17, pl. xxxvi, figs. 13, 16, 17.

⁴ 'Pal. Franç. Terr. Crét.,' vol. iii (1845), p. 324, pl. cccl, figs. 8—10. This species has been recorded by Barrois from the Upper Greensand of Lulworth and Devizes; I have not seen any examples from those localities.

⁵ 'Palæont. Indica, Cret. Fauna S. India' (1870), p. 101, pl. i, figs. 12, 13.

Family—SAXICAVIDÆ, Gray.

Genus—PANOPEA, *Ménard de la Groye*, 1807.

(*Ann. Mus. Hist. nat., Paris,* vol. ix, p. 131, pl. xii.)

PANOPEA, sp. Text-fig. 27.

Internal casts of a large, convex *Panopea* occur in the Tealby Limestone of

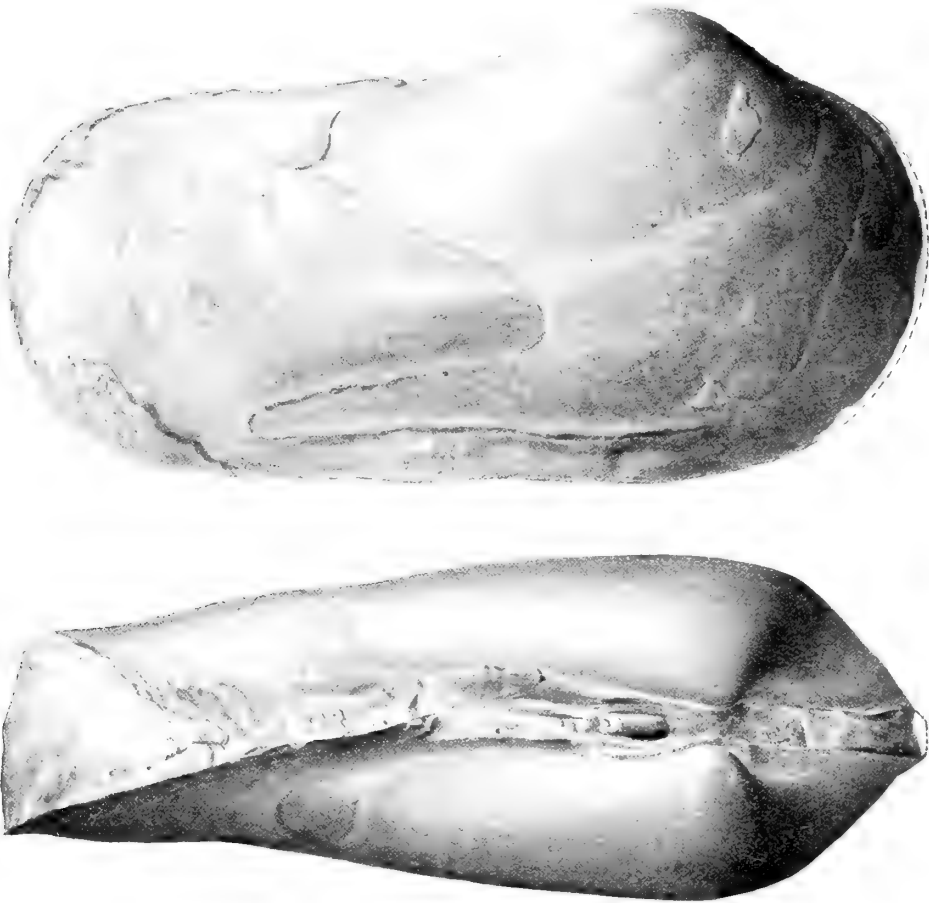


FIG. 27.—*Panopea*, sp. Tealby Limestone, North Willingham, Lincolnshire. Sedgwick Museum, Cambridge. $\times \frac{7}{5}$.

Hainton, Claxby, and North Willingham, Lincolnshire. In form they resemble some varieties of *P. gurgitis*, but the posterior part of the shell is more elongated. One specimen shows a large external ligament, and on a small portion of shell indications of radial rows of fine granules are seen. The pallial sinus is large and rounded.

PANOPEA SPILSBIENSIS, sp. nov. Plate XXXVIII, fig. 2 *a, b*.

Description.—Shell elongate-oval, convex, not very inequilateral. Posterior part more compressed and not so high as the median and anterior parts. Anterior margin rounded; ventral margin slightly curved, not quite parallel to the long dorsal margin. Umbones broad, incurved, at about six-fifteenths of the entire length from the anterior end. Pallial sinus large, deep, and rounded. Surface of shell nearly smooth.

Remarks.—Only a few internal casts with small portions of the shell preserved have been obtained, but they seem to differ considerably from other species and are provisionally referred to the genus *Panopea*.

Distribution.—Spilsby Sandstone (zone of *Belemnites lateralis*) of Donnington.

PANOPEA GURGITIS (*Brongniart*), 1822. Plate XXXV, figs. 9—14; Plate XXXVI, figs. 1—8.

1822. LUTRARIA GURGITIS, *A. Brongniart*, in *Cuvier*. Ossements Foss., vol. ii, pt. 2, pp. 333, 615, pl. ix, fig. 15.
1823. MYA PLICATA, *J. de C. Sowerby*. Min. Conch., vol. v, p. 20, pl. cccxix, fig. 3.
1835. PANOPÆA PLICATA, *Sowerby*. Ibid., vol. vi, Systemat. Index, p. 241.
1841. — — *F. A. Römer*. Die Verstein. d. nord-deutsch. Kreidegeb., p. 75, pl. ix, fig. 25.
1842. PHOLADOMYA NEOCOMIENSIS, *A. Leymerie*. Mém. Soc. géol. de France, ser. 2, vol. v, p. 3, pl. iii, fig. 4.
- — PREVOSTI, *Deshayes* in *Leymerie*. Ibid., p. 3, pl. ii, fig. 7.
1845. PANOPÆA NEOCOMIENSIS, *A. d'Orbigny*. Pal. Franç. Terr. Crét., vol. iii, p. 329, pl. cccli, figs. 3—8.
- — PREVOSTI, *d'Orbigny*. Ibid., p. 334, pl. ccclvi, figs. 3, 4.
- — NEOCOMIENSIS, *E. Forbes*. Quart. Journ. Geol. Soc., vol. i, p. 238.
- — PLICATA, *Forbes*. Ibid., p. 238.
- MYOPSIS NEOCOMIENSIS, *L. Agassiz*. Études crit. Moll. Foss., Myes, p. 257, pl. xxxi, figs. 5—10.
- — UNIOIDES, *Agassiz*. Ibid., p. 258, pl. xxxi, figs. 11, 12.
1850. PANOPÆA NEOCOMIENSIS, *A. d'Orbigny*. Prodr. de Pal., vol. ii, pp. 73, 117.
- — PREVOSTII, *d'Orbigny*. Ibid., pp. 105, 117.
1852. — — PLICATA, *F. J. Pictet and W. Roux*. Moll. Foss. Grès verts de Genève, p. 399, pl. xxviii, fig. 2.
- — RHODANI, *Pictet and Roux*. Ibid., p. 400, pl. xxviii, fig. 3.
1854. MYACITES NEOCOMIENSIS, *J. Morris*. Cat. Brit. Foss., ed. 2, p. 213.
1855. PANOPÆA — *F. J. Pictet and E. Renevier*. Foss. Terr. Aptien (Matér. Pal. Suisse, ser. 1), pp. 56, 175, pl. vi, figs. 2, 3.
- — PLICATA, *Pictet and Renevier*. Ibid., p. 57, pl. vi, figs. 4, 5.

1855. *PANOPEA NEOCOMIENSIS*, *G. Cotteau*. Moll. Foss. de l'Yonne, p. 51.
1861. — — — *P. de Loriol*. Anim. Invert. Foss. Mt. Salève, p. 55.
- 1864-5. — — — *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 49, pl. c, figs. 10-12.
1865. — *PLICATA*, *Pictet and Campiche*. Ibid., p. 63.
1869. — *NEOCOMIENSIS*, *P. de Loriol and V. Gilliéron*. Urgon. infér. de Landeron, p. 10, pl. i, fig. 10.
1870. — — — *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 87.
1877. — *PUNCTATO-PLICATA*, *G. Böhm*. Zeitschr. d. deutsch. geol. Gesellsch., vol. xxix, p. 241.
- ? 1883. — *PLICATA*, *W. Keeping*. Foss., etc., Neoc. Upware and Brickhill, p. 126.
1884. — *NEOCOMIENSIS*, *O. Weerth*. Die Fauna des Neocom. im Teutoburg. Walde (Palæont. Abhandl., vol. ii), p. 37, pl. viii, fig. 7.
1886. *PLEUROMYA* — — *H. Trautschold*. Néocom. de Sably (Nouv. Mém. Soc. Impér. Nat. Moscou, vol. xv), p. 135.
1892. *PANOPEA* — — *O. Behrendsen*. Zeitschr. d. deutsch. geol. Gesellsch., vol. xlv, p. 20.
1895. — — — *G. Maas*. Ibid., vol. xlvii, p. 256.
- — — *F. Vogel*. Holländisch. Kreide, p. 59.
1896. — — — *A. Wollemaun*. Zeitschr. d. deutsch. geol. Gesellsch., vol. xlviii, p. 849.
1897. *PLEUROMYA PLICATA*, *R. B. Newton*. Proc. Dorset Nat. Hist. and Antiq. Field Club, vol. xviii, pp. 71, 93, pl. ii, figs. 4, 5.
1898. — — *NEOCOMIENSIS*, *E. G. Skeat and V. Madsen*. Jur. Neoc. and Gault Boulders in Denmark (Danmarks geol. Undersög., 2 R., Nr. 8), p. 185, pl. vi, fig. 11.
1900. *PANOPEA* — — *A. Wollemaun*. Die Biv. u. Gastrop. d. deutsch. u. holländ. Neocoms (Abhandl. d. k. preussisch. geol. Land., N. F., pt. 31), p. 124.
1905. — — — *E. Harbort*. Die Fauna d. Schaumburg-Lippe'schen Kreidemulde (ibid., pt. 45), p. 74.
1906. — — — *A. Wollemaun*. Jahrb. d. k. preuss. geol. Landesanst. für 1906, vol. xxvii, p. 278.
1908. — — — *A. Stojanoff*. Ann. géol. et min. de la Russie, vol. x, p. 115.
- Non 1827. *LUTRARIA GURGITIS*, *S. Nilsson*. Petrif. Suecana, p. 18, pl. v, fig. 9 (*Glycimeris Holzapfeli*, Hennig).
- 1837. — — — *W. Hisinger*. Lethæa Suecica, p. 67, pl. xx, fig. 1.

- Non 1840. *PANOPÆA GURGITES*, *A. Goldfuss*. Petref. Germ., vol. ii, p. 274, pl. cliii, fig. 7 (*P. Goldfussi*, d'Orbigny, 1850).
- — — *PLICATA*, *Goldfuss*. Ibid., p. 274, pl. clviii, fig. 5.
- 1845. — *GURGITES*, *A. d'Orbigny*. Pal. Franç. Terr. Crét., vol. iii, p. 345, pl. ccclxi, figs. 1, 2.
- 1846. — — *A. E. Reuss*. Die Verstein. der böhm. Kreideformat., pt. 2, p. 17, pl. xxxvi, fig. 3.
- 1847. — *PLICATA*, *J. Müller*. Petref. der Aachen. Kreidef., pt. 1, p. 28 (*Glycimeris Geinitzi*, Holzapfel).
- 1873. — *GURGITES*, *H. B. Geinitz*. Das Elbththalgeb. in Sachsen (Palæontographica, vol. xx, pt. 2), p. 68, pl. xix, figs. 1, 2.
- 1876. — — *D. Brauns*. Zeitschr. f. d. gesamt. Naturwiss., vol. xlv, p. 362.
- 1877. — — *A. Fritsch*. Stud. im Gebiete der böhm. Kreideformat., ii, Weissenberg. u. Malnitz. Schichten, p. 125, fig. 100.
- 1898. *GLYCIMERIS* — *G. Müller*. Die Mollusk. d. Untersenon v. Braunschweig u. Ilsede, p. 70, pl. x, fig. 4.
- 1901. *PANOPÆA* — *F. Sturm*. Jahrb. d. k. preuss. geol. Landesanst. für 1900, vol. xxi, p. 70, pl. x, fig. 4.

Description.—Shell more or less oblong, rounded, convex; posterior part somewhat compressed, anterior part sloping more or less rapidly to the margin; moderately or considerably inequilateral; posterior gape large. Anterior margin more or less convex, sometimes subtruncate; antero-ventral margin rounded; ventral margin slightly or moderately convex, nearly parallel to the dorsal margin; posterior margin convex, or subtruncate and rounded; postero-dorsal margin nearly straight. Umbones incurved, often broad, sometimes narrow and pointed; the dorsal part of the shell in front of the umbones is moderately or considerably depressed; sometimes a more or less distinct carina extends from the umbo towards the antero-ventral extremity; another carina, usually faint, may extend from the umbo posteriorly. Pallial sinus large, rounded.

Ornamentation consists of concentric folds, which may be conspicuous or only faintly indicated, and of numerous radial rows of minute granules.

Measurements:

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Length	. 93	. 80	. 69	. 65	. 61	. 56	. 50	. 43	. 33 mm.
Height	. 49	. 46	. 36	. 38	. 35	. 29	. 29	. 24	. 19 „

(1, 5) *Perna*-bed, Atherfield.

(3, 4, 6—9) Crackers, Atherfield.

(2) Ferruginous Sands, Shanklin.

Affinities.—This species has been referred by most authors to the genus

Panopea, but by some to *Pleuromya*.¹ There seems now to be sufficient evidence to show that it belongs to the former rather than the latter, since the hinge-margins of the two valves are alike and there is no overlap of left by the right margin; the hinge possesses the prominent, conical tooth characteristic of *Panopea* (Plate XXXVI, fig. 6); and a well-developed, broad, external ligament is present (Plate XXXV, figs. 9 *b*, 11 *b*). The fine radial ornamentation (Plate XXXV, figs. 9 *c*, 13 *b*) agrees perfectly with that found in Tertiary species of *Panopea*.² I have not seen the hinge in any specimen from the Lower Greensand, but it is well preserved in a left valve from Blackdown. Pictet and Campiche³ state that casts from the Aptian show clearly the presence of the teeth of *Panopea*.

Pictet and Renevier thought that *P. plicata* (Sowerby) and *P. neocomiensis* (Leymerie) should be united as one species; Pictet and Campiche, however, in a later work regarded them as distinct, and stated that the former differs from the latter by the possession of strong concentric folds and by the absence of fine radial ornamentation. But when numerous specimens are examined all stages in the strength of the folds can be seen; and those with well-developed folds show, when the surface is well-preserved, the same kind of radial ornamentation that occurs on specimens with indistinct folds. The presence of a carina in front of the umbones and the somewhat smaller height of the posterior part of the shell have also been mentioned as characteristic of *P. neocomiensis*, but these features are now known to be inconstant. It appears, therefore, that there is no character by which *P. plicata* can be separated from *P. neocomiensis*.

It is evident from Brongniart's remarks that his specimens of *Lutraria gurgitis* came from the Perte-du-Rhône. Pictet and Renevier,⁴ who had seen the type of that species in the collection of M. Deluc, recognised it as a specimen from the Aptian of the Perte-du-Rhône, and state that it is certainly an example of either *P. neocomiensis* or *P. plicata*. Since these two forms are now united it follows that the earlier name given by Brongniart should be used for this species. Later writers have unfortunately used the name *gurgitis* for a species from the Chalk.

P. acutisulcata (Deshayes⁵) and *P. Schröderi* (Wollemann⁶) appear to be closely allied to *P. gurgitis*.

¹ For an account of the characters of this genus see Terquem, 'Bull. Soc. géol. de France,' ser. 3, vol. x (1853), p. 534, and "Observations sur les Études critiques des Mollusques Fossiles comprenant la monographie des Myaires de M. Agassiz," 'Mém. Acad. Imp. de Metz,' année 1854—55 (1855), p. 253.

² See, for instance, *P. intermedia* (Sow.) from the London Clay, etc., and *P. floridana*, Heilprin, from the Caloosahatchie Beds of Florida.

³ 'Terr. Crét. Ste. Croix' (1865), p. 51.

⁴ 'Foss. Terr. Aptien' ('Matér. Pal. Suisse,' ser. 1, 1855), pp. 56 (footnote), 175.

⁵ Leymerie, 'Mém. Soc. géol. de France,' ser. 2, vol. v (1842), p. 3, pl. iii, fig. 2; d'Orbigny, 'Pal. Franç. Terr. Crét.,' vol. iii (1845), p. 336, pl. cccvii, figs. 1—3; Pictet and Campiche, 'Terr. Crét. Ste. Croix' ('Matér. Pal. Suisse,' ser. 4, 1865), p. 65.

⁶ 'Die Biv. u. Gastrop. d. deutsch. u. holländ. Neocoms' ('Abhandl. d. k. preussisch. geol. Land., N. F., pt. 31, 1900), p. 126, pl. v, fig. 7.

P. læviuscula (Sowerby¹), from the Upper Greensand of Blackdown, closely resembles the small forms of the *neocomiensis* variety of *P. gurgitis* and does not appear to be specifically distinct. The type consists of an imperfect right valve; a specimen similar to the type, but with both valves preserved, is in the Museum of Practical Geology (No. 23,823).

Remarks.—Previous writers have remarked on the great amount of variation shown by this species. At first sight some of the varieties appear to be distinct, but, as Wollemaun has pointed out, when a large number of specimens are studied, transitions can be traced between the different forms. The varieties do not appear to be confined to definite horizons, and nearly all of them are found together in the *Perna*-bed and Crackers of Atherfield.

Considerable differences are seen in the position of the umbones, so that some specimens are much more inequilateral than others; in those in which the anterior part is relatively short the anterior slope is rapid. The size and depth of the depression in the lunular region show considerable variation; when large and deep the umbones are usually narrower and more pointed than when the depression is small and shallow, and in the former case the carina extending from the umbo to the antero-ventral margin is usually distinct. The relative length and height of the shell, the rounded or truncate character of the anterior margin, the curvature of the ventral margin, the height of the posterior end, and the convexity of the anterior compared with that of the posterior part of the shell also show more or less considerable differences. The concentric folds may be conspicuous, but are sometimes indistinct; sometimes they appear to be better marked on internal casts than on the shell itself; in some cases their prominence is due to the state of preservation of the shell; thus Wollemaun mentions a specimen in which one valve is weathered and shows strong folds, whilst the other valve is well preserved and nearly smooth.

Some forms of this species are represented by a larger number of individuals than others. One common form (Plate XXXVI, figs. 3, 4), agrees more or less closely with the type of *P. plicata* (Sowerby), and it may perhaps be convenient to refer to this as *P. gurgitis* var. *plicata*. In this the concentric folds are usually prominent, the ventral margin is only slightly curved, the posterior part of the shell is of nearly the same height as the anterior part, and the lunular depression is distinct and usually large.

Another form (Plate XXXV, figs. 9, 13) resembles *P. neocomiensis* (Leymerie) and may be referred to as *P. gurgitis* var. *neocomiensis*. The concentric folds are

¹ *Mya læviuscula*, J. de C. Sowerby, 'Trans. Geol. Soc.,' ser. 2 (1836), vol. iv, pp. 241, 340, pl. xvi, fig. 6; Morris, 'Cat. Brit. Foss.,' ed. 2 (1854), p. 212. *Panopæa læviuscula*, d'Orbigny, 'Prodr. de Pal.,' vol. ii (1850), p. 157; Pictet and Campiche, 'Terr. Crét. Ste. Croix' ('Matér. Pal. Suisse,' ser. 4, 1865), p. 70.

usually less distinct than in the variety *plicata*, the lunular depression is smaller and shallower, the umbones broader, and the ventral margin usually more distinctly curved. The smaller specimens of the var. *neocomiensis* resemble the example figured by d'Orbigny, in which the anterior margin is obliquely truncated, and a carina extends from the umbo antero-ventrally.

In one form (Plate XXXV, fig. 10), which in other respects resembles the variety *neocomiensis*, the anterior half of the shell is relatively more inflated, and the posterior part is not so high as the anterior part; this form may be known as *P. gurgitis* var. *a*. In addition to these forms of *P. gurgitis* numerous other modifications occur.

Specimens from the Speeton Clay have been recorded by previous writers as *P. neocomiensis*; the examples seen are few in number and not well preserved, but resemble closely the smaller form of *P. gurgitis* var. *neocomiensis* (Plate XXXV, fig. 13). In one case the fine, radial ornamentation is shown.

Specimens from Blackdown (Plate XXXVI, figs. 6, 7) resemble the variety *plicata* from the Lower Greensand, but are somewhat less convex; these probably constitute only a local variety, since examples from the Upper Greensand of Dorset agree in convexity and in other characters with typical forms of the var. *plicata* from the Lower Greensand. The examples from Blackdown, although few in number, show considerable variation; one specimen (Plate XXXVI, fig. 8), is much shorter than usual, and resembles d'Orbigny's¹ figure of *P. plicata*, but is less convex.

Crushed internal casts of *Panopea* have been found in the Chalk Marl of Folkestone; they resemble *P. gurgitis* var. *plicata*, but their imperfect preservation renders determination difficult.

Types.—The type of *P. gurgitis* came from the Aptian of the Perte-du-Rhône; that of *P. neocomiensis* from the Neocomian of Aube. The type of *P. plicata* was obtained from the Lower Greensand of Sandgate, but cannot now be found. The type of *P. læviuscula*, from the Upper Greensand of Blackdown, is in the Bristol Museum.

Distribution.—Lower Greensand: *Perna*-bed, Crackers and Beds iv, vi, vii, x, xiii, and xiv of Atherfield. *Perna*-bed of Sandown. Ferruginous Sands of Shanklin. Atherfield Beds of East Shalford and Sevenoaks. Hythe Beds of Hythe and Court-at-Street. Sandgate Beds of Parham Park. *Mammillatus* Bed of Folkestone. Recorded by Topley from the Atherfield Clay of Haslemere, Peasmarsh, Redhill, and Hythe; from the Hythe Beds of Pulborough; from the Sandgate Beds of Folkestone and Sandgate; and from the Folkestone Beds of Folkestone. ? Lower Greensand of Upware. ? Speeton Clay of Speeton. Gault of Black Ven and Folkestone. Upper Greensand of Blackdown and Black Ven.

¹ 'Pal. Franç. Terr. Crét.,' vol. iii (1845), p. 337, pl. cclvii, figs. 4, 5.

PANOPEA MANDIBULA (*Sowerby*), 1813. Plate XXXVII, figs. 1—5.

1813. MYA MANDIBULA, *J. Sowerby*. Min. Conch., vol. i, p. 93, pl. xliii.
 ? 1840. PANOPEA BAUMONTII, *A. Goldfuss*. Petref. Germ., vol. ii, p. 274, pl. clviii,
 fig. 4.
 ? 1841. — JUGLERI, *F. A. Römer*. Die Verstein. d. nord-deutsch. Kreidegeb.,
 p. 75, pl. x, fig. 4.
 1845. — MANDIBULA, *A. d'Orbigny*. Pal. Franç. Terr. Crét., vol. iii, p. 344,
 pl. ccclx, figs. 3, 4.
 1850. — — *H. B. Geinitz*. Das Quadersandst. oder Kreidegeb.
 in Deutschland, p. 146.
 1854. MYACITES MANDIBULA, *J. Morris*. Cat. Brit. Foss., ed. 2, p. 213.
 1865. PANOPEA — *F. J. Pictet and G. Campiche*. Terr. Crét. Ste. Croix
 (Matér. Pal. Suisse, ser. 4), p. 70.
 1870. — — *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India,
 vol. iii, p. 87.
 1873. — — *H. B. Geinitz*. Das Ellbthalgeb. in Sachsen (Pal-
 æontographica, vol. xx, pt. 2), p.
 70, pl. xviii, figs. 20, 21.
 ? 1883. — — *A. Fritsch*. Stud. im Gebiete der böhm. Kreide-
 format., iii, Iersschicht., p. 108.
 ? 1897. — — *Fritsch*. Ibid., vi, Chlomek. Schicht., p. 60.
 1900. PLEUROMYA — *A. J. Jukes-Browne*. Cret. Rocks of Britain, vol. i,
 p. 470.

Description. — Shell oblong or rhomboidal in outline, very inequilateral, convex, anterior part sloping rapidly to the anterior margin, with a wide posterior gape. Anterior margin somewhat convex; antero-ventral extremity rounded; ventral margin straight or slightly curved and nearly parallel to the dorsal margin; postero-ventral extremity rounded; posterior margin truncated, nearly straight, either perpendicular or slightly oblique to the nearly straight postero-dorsal margin. Umbones prominent, narrow, pointed, considerably incurved, with a broad, shallow furrow extending from their posterior side to the postero-ventral part of the valves. In front of the umbones the shell is considerably depressed.

Ornamentation consists of strong, rounded, concentric folds, which become less distinct in and posterior to the dorso-ventral furrow; and of radial rows of minute granules.

Measurements :

	(1)	(2)	(3)	(4)	(5)	(6)
Length .	72	70	53	53	49	36 mm.
Height .	57	46	41	38	35	33 „
Thickness .	41	39	—	28	26	27 „

(1, 4—6) Upper Greensand, Ventnor.

(2, 3) Upper Greensand, Devizes.

Affinities.—The more elongate forms of this species resemble some specimens of *P. gurgitis* var. *plicata*, but are more inequilateral, more convex, usually relatively longer, with narrower and more pointed umbones, and with a distinct furrow extending from the umbo to the postero-ventral margin.

Remarks.—Many of the specimens are more or less crushed, and nearly all are internal casts, but the shell is preserved in some specimens from the Gault, and shows radial rows of fine granules. The hinge is not seen in any instance. *P. mandibula* is common in the Upper Greensand of Ventnor and Devizes, and is less abundant at other horizons. The principal variation seen is in the relative length and height of the shell.

Type.—From the Upper Greensand of Devizes, in the British Museum.

Distribution.—Lower Greensand of Atherfield. Atherfield Beds of Sevenoaks. Sandgate Beds of Nutfield. Folkestone Beds of Folkestone. Upper Greensand (zone of *Schlaenbachia rostrata*) of Devizes and Ventnor. Gault and Upper Greensand of Black Ven. Chalk Marl of Folkestone.

PANOPEA OVALIS, *Sowerby*, 1836. Plate XXXVII, fig. 6*a, b*.

1836. PANOPEA OVALIS, *J. de C. Sowerby*. Trans. Geol. Soc., ser. 2, vol. iv, pp. 241, 340, pl. xvi, fig. 5.
 1850. — — — *A. d'Orbigny*. Prodr. de Pal., vol. ii, p. 157.
 1854. MYACITES — *J. Morris*. Cat. Brit. Foss., ed. 2, p. 214.

Description.—Shell oval, convex, moderately inequilateral. Antero-dorsal margin slightly convex; anterior margin rounded, passing gradually into the slightly convex ventral margin. Umbones broad, incurved. The parts of the shell in the front of and behind the umbones are considerably depressed. The surface is ornamented with growth-rings.

Remarks.—The only specimen seen is the type, in which the posterior part of the shell is not preserved.

Type.—In the British Museum.

Distribution.—Upper Greensand (zone of *Schlaenbachia rostrata*) of Blackdown.

PANOPEA MEYERI, sp. nov. Plate XXXVIII, fig. 1*a, b*.

Description.—Shell oval, moderately convex, with flattened sides, slightly inequilateral, with a wide posterior gape. Antero-dorsal margin convex. Anterior

margin rounded. Ventral margin straight or slightly convex. Posterior margin truncated, slightly convex. Postero-dorsal margin slightly concave, nearly parallel to the ventral margin. Umbones broad, curved inwards and backwards. The part of the shell in front of the umbones is slightly depressed; the part behind the umbones is more deeply depressed. Surface with well-marked growth-rings. Length 87 mm.; height 59 mm.

Affinities.—In this species the sides of the shell are more flattened, the antero-dorsal margin is more convex, and the part of the shell in front of the umbones is less depressed than in *P. ovalis*. The hinge has not been seen, but the form of the shell agrees closely with that of typical species of *Panopea*.

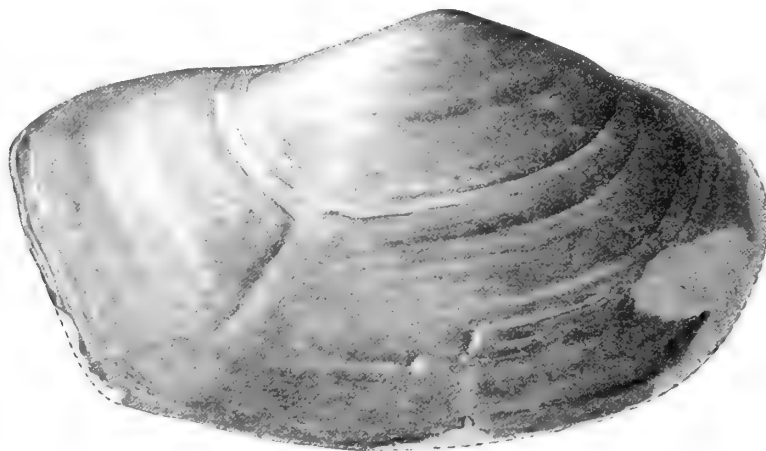


FIG. 28.—*Panopea*, sp. Lower Greensand ("Scaphites" Beds), Whale Chine, Atherfield. Sedgwick Museum. Internal cast of right valve. Natural size.

Remarks.—In addition to the specimen figured, which was collected by C. J. A. Meÿer, an internal cast and the posterior part of a left valve only have been seen.

Distribution.—Upper Greensand (zone of *Schlenbachia varians*) of Blackdown.

PANOPEA, sp. Text-fig. 28.

Internal casts resembling *P. Meyeri*, but with the posterior border obliquely truncated, occur in the Lower Greensand ("Scaphites" Beds) of Whale Chine, Atherfield.

Family—PHOLADIDÆ, *Leach*.*Genus*—MARTESIA, *Leach* in *H. M. D. de Blainville*, 1825.

('Manuel de Malacol,' p. 632.)

MARTESIA CONSTRICTA (*Phillips*), 1829. Plate XXXVIII, figs. 3—10.

1829. PHOLAS CONSTRICTA, *J. Phillips*. Geol. Yorks., p. 169 (p. 256, ed. 3), pl. ii, fig. 17.
1850. — — — *A. d'Orbigny*. Prodr. de Pal., vol. ii, p. 117.
1854. — — — *J. Morris*. Cat. Brit. Foss., ed. 2, p. 221.
1864. — — — *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 26.
1870. — — — *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, p. 23 (? *Martesia*).
1900. PHOLADIDEA CONSTRICTA, *A. J. Jukes-Browne*. Cret. Rocks of Britain, vol. i, p. 470.

Description.—Shell small, more or less elongate; anterior part short, convex, rounded; posterior part wedge-shaped. Umbones prominent, close together, curved inwards and forwards. Ventral margin nearly straight. Posterior margin sub-truncate, more or less rounded, somewhat oblique. Postero-dorsal margin sloping ventrally. Two narrow furrows, with corresponding internal ribs, extend from the umbo to the ventral margin; the anterior furrow is rather broader and less oblique than the posterior, but is sometimes short or absent. An internal ridge, near the postero-dorsal margin, extends from the umbo to near the posterior adductor. Anterior callus shield-shaped. Ventral margin of valves diverging posteriorly, joined by a hypoplax. Metaplax elongated, divided.

Ornamentation: on the larger part of the shell distinct, regular, concentric ribs with minute transverse serrations. In front of the anterior furrow the ribs become smaller and closer together; they bend dorsally and unite at an angle with similar ribs on the dorsal part of the anterior end of the valve. On the postero-dorsal part of the shell the ribs are less regular and less distinct.

Measurements:

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	
Length	18	17	16	18	15	14	10	mm.
Height	9	9	9	10	9	7	6·5	„
Thickness	9	9	9	10·5	9	7·5	6·5	„

(1—3) Speeton, (4—7) Folkestone.

Affinities.—This species is less elongate than *M. subcylindrica* (d'Orbigny).¹¹ 'Pal. Franç. Terr. Crét.,' vol. iii (1845), p. 306, pl. cccxlix, figs. 5—8.

The height of the anterior part of the shell is less and the length of the ventral margin greater relatively than in *M. Sanctæ-Crucis* (Pictet and Campiche).¹

Remarks.—This species varies somewhat in relative length and breadth, and in the extent of the development of the anterior furrow. Many of the specimens are found in burrows in wood. The protoplax is not preserved in any example seen.

Type.—The type came from Speeton, but cannot now be found.

Distribution.—Speeton Clay of Speeton. Lower and Upper Gault of Folkestone. Probably also in the Upper Greensand of Blackdown. Specimens which belong to either this or a closely allied species occur in the Spilsby Sandstone of Benniworth Haven. Borings in wood found in the Tealby Limestone of Claxby may be due to this species but the valves are concealed.

MARTESIA PRISCA (*Sowerby*), 1828. Plate XXXVIII, fig. 11.

- 1828. PHOLAS PRISCUS, *J. de C. Sowerby*. Min. Conch., vol. vi, p. 157, pl. dlxxxii.
- 1845. PHOLAS ? PRISCUS, *E. Forbes*. Quart. Journ. Geol. Soc., vol. i, p. 237.
- 1850. PHOLAS PRISCA, *A. d'Orbigny*. Prodr. de Pal., vol. ii, p. 72.
- 1854. — — *J. Morris*. Cat. Brit. Foss., ed. 2, p. 221.
- 1864. — — *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix
(Matér. Pal. Suisse, ser. 4), p. 26.
- 1870. — — (MARTESIA), *F. Stoliczka*. Palæont. Indica, Cret. Fauna
S. India, vol. iii, p. 22.
- 1875. PHOLADIDEA PRISCA, *R. Etheridge* in *W. Topley*. Geol. Weald, p. 419.

This species appears to be closely related to *M. constricta*, but no satisfactory description can be given until better specimens have been obtained. The type, in which the shell was well preserved, cannot now be traced; in other examples the shell is concealed by a coating of hard matrix, and in the few cases in which it has been possible to remove the matrix only internal casts of the valves have been exposed. The type came from the Lower Greensand (? Sandgate Beds) near Sandgate. Other specimens have been obtained from the Hythe Beds of Hythe and Maidstone.²

¹ 'Foss. Terr. Crét. Ste. Croix' (1864), p. 24, pl. c, fig. 1. This species has been recorded by Price from the Gault of Folkestone; I have not seen any examples of it.

² *Fistulana pyriformis*, Mantell, is perhaps a *Martesia*, but no specimens showing the valves have been seen. No figure or specific description was given by Mantell. The "type" came from Willingdon near Eastbourne, apparently from the top of the Lower Greensand. Mantell, 'Foss. S. Downs' (1822), p. 76; *Gastrochæna pyriformis*, Morris, 'Cat. Brit. Foss.,' ed. 2 (1854), p. 203; Pictet and Campiche, 'Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse,' ser. 4, 1864), p. 18; Stoliczka, 'Palæont. Indica, Cret. Fauna S. India,' vol. iii (1870), p. 29.

Gastrochæna dilatata, Deshayes, has been recorded by Forbes and other writers from the Lower Greensand; I have not seen any specimens in which the valves are exposed. Deshayes, in Leymerie, 'Mém. Soc. géol. de France,' vol. v (1842), p. 2, pl. iii, fig. 1; Forbes, 'Quart. Journ. Geol. Soc.,' vol. i (1845), p. 237; Pictet and Campiche, 'Foss. Terr. Crét. Ste. Croix' (1864), p. 11, pl. xcix, figs. 4, 5.

MARTESIA ? ROTUNDA (*Sowerby*), 1850. Plate XXXVIII, figs. 12 *a—c*, 13.

1850. TEREDO ROTUNDUS, *J. de C. Sowerby* in *F. Dixon*. Geol. Sussex, p. 346 (p. 382, ed. 2), pl. xxviii, figs. 27, 28.
 1854. — — — *J. Morris*. Cat. Brit. Foss., ed. 2, p. 227.
 1897. MARTESIA ? ROTUNDA, *H. Woods*. Quart. Journ. Geol. Soc., vol. liii, p. 393, pl. xxviii, figs. 15—18.

Description.—Shell small, ovoid, inflated, with rounded outline. Anterior gape large, apparently closed by callus. Umbones sub-median, curved inwards and forwards. A strong groove and a corresponding internal rib pass from the umbo to the ventral margin. Near the dorsal margin a strong, narrow internal rib passes backward from the umbo but does not reach the posterior margin. Ornamentation posterior to the groove consists of concentric ribs and of two radial ribs immediately behind the groove; anterior to the groove are a few regular radial ribs, and concentric ribs parallel to the margin of the anterior gape. Length, 7 mm.; height, 5.5 mm.; thickness, 5 mm.

Remarks.—I have seen only three casts of the interior and two of part of the exterior of this species, so that at present it is difficult to determine satisfactorily its generic position.

Type.—The type came from the Chalk of Kent, but cannot now be found.

Distribution.—Chalk Rock of Cuckhamsley (Berkshire), and of Whyteleafe (Surrey).

Genus—TURNUS, *W. M. Gabb*, 1864.

(‘Geol. Surv. California,’ Palæontology, vol. i, p. 145.)

TURNUS DALLASI (*Walker*), 1866. Plate XXXVIII, figs. 14 *a, b*, 15.

1866. PHOLAS DALLASI, *J. F. Walker*. Ann. Mag. Nat. Hist., ser. 3, vol. xviii, p. 386, pl. xiii, figs. 3, 4.

Description.—Shell ovate, short, inflated in front, wedge-like behind. Margin of the anterior gape oblique, gently curved. Posterior margin rounded. Umbones prominent, curved inwards and forwards. A narrow furrow, and a corresponding internal rib, extend from the umbo to the ventral margin in a somewhat oblique direction, and the furrow is crossed by small ribs. A broad and strong internal rib

passes from the umbo to near the postero-ventral margin. The shell is ornamented with small concentric ribs, which bend dorsally in front of the furrow and become parallel to the anterior margin.

Measurements :

	(1)	(2)
Length	15	8 mm.
Height	11	6.5 „
Thickness	—	6.5 „

Affinities.—The very slight curvature of the anterior margin and of the anterior ribs distinguishes this species from the one described below.

Remarks.—*T. Dallasi* occurs commonly boring in wood.

Type.—From Potton; in the Sedgwick Museum.

Distribution.—Lower Greensand of Potton.

TURNUS, sp. Plate XXXVIII, figs. 16, 17.

Description.—Shell oval, inflated, posterior end wedge-like. Ventral margin curved; posterior margin rounded. Antero-ventral excavation angular. Umbones prominent, anterior, incurved, close together. An external furrow and a corresponding internal rib extend from the umbo to the ventral margin. A strong internal rib passes from the umbo to near the postero-ventral edge.

Posterior to the dorso-ventral groove the shell is ornamented with narrow, regular concentric ribs; for a short distance in front of the groove the ribs bend sharply upwards, and soon become smaller and close together; on the dorsal part of the anterior end the ribs bend forwards.

Measurements :

	(1)	(2)
Length	14	13 mm.
Height	11	9.5 „
Thickness	12	10 „

(1—2) Gault, Folkestone.

Affinities.—This species resembles *T. argonnensis* (Buvignier),¹ but exact comparison is difficult since only a small internal cast is figured by Buvignier. The English form appears to differ from *T. argonnensis* in the larger size and more angular character of the anterior gape, and in the smaller and closer ribs, especially on the anterior part of the shell.

Distribution.—Lower Gault of Folkestone.

¹ 'Statist. géol. min. et paléont. de la Meuse,' Atlas (1852), p. 6, pl. vi, figs. 33—39.

TURNUS, sp. Plate XXXVIII, fig. 18.

A specimen from the Upper Greensand of Blackdown resembles the species from the Gault, described above, but the concentric ribs are finer and more numerous, and the dorso-ventral furrow is narrower. The exterior of a left valve only is preserved and is associated with large and rather irregular tubes.

TURNUS ? AMPHISBÆNA (*Goldfuss*), 1831. Plate XXXVIII, figs. 19, 20.

1822. TEREDO, *G. Mantell*. Foss. S. Downs, p. 207, pl. xviii, fig. 23.
1831. SERPULA AMPHISBÆNA, *A. Goldfuss*. Petref. Germ., vol. i, p. 239, pl. lxx, fig. 16.
- ? 1839. CERAMBYCITES, sp., *H. B. Geinitz*. Char. d. Schicht. u. Petref. des sächs. Kreidegeb., pt. 1, p. 13, pls. iii—vi.
1840. TEREDO AMPHISBÆNA, *J. de C. Sowerby*. Min. Conch., vol. vii, p. 17, pl. dcviii, figs. 1—5 (*Teredo articulata* on the plate).
1841. SERPULA AMPHISBÆNA, *F. A. Römer*. Die Verstein. d. nord-deutsch. Kreidegeb., p. 100.
1842. — — — *H. B. Geinitz*. Char. d. Schicht. u. Petref. des sächs.-böhmisch. Kreidegeb., pt. 3, p. 65.
1843. FISTULANA AMPHISBÆNA, *H. B. Geinitz*. Die Verstein. von Kieslingswalda, p. 11, pl. iv, figs. 11—14.
1845. SERPULA AMPHISBÆNA, *A. E. Reuss*. Die Verstein. der böhm. Kreideformat., pt. 1, p. 19, pl. v, figs. 29—32.
1846. GASTROCHÆNA ? (TEREDO ?) AMPHISBÆNA, *H. B. Geinitz*. Grundr. d. Verstein., p. 396.
- ? 1850. FISTULANA AMPHISBÆNA, *P. de Ryckholt*. Mélanges Paléont. i (Mém. cour. et Mém. des sav. étrang., vol. xxiv), p. 117, pl. v, figs. 19—22.
1850. TEREDO AMPHISBÆNA, *J. de C. Sowerby*, in *F. Dixon*. Geol. Sussex, p. 354 (p. 385, ed. 2), pl. xxviii, fig. 35.
1851. GASTROCHÆNA AMPHISBÆNA, *J. Müller*. Petref. der Aachen. Kreidef., pt. 2, p. 63.
- ? 1852. — — — ? *R. Kner*. Denkschr. d. k. Akad. d. Wissensch. Wien, Math.-nat. Cl., vol. iii, p. 310, pl. xvi, fig. 18.
1854. TEREDO AMPHISBÆNA, *J. Morris*. Cat. Brit. Foss., ed. 2, p. 227.
1863. GASTROCHÆNA AMPHISBÆNA, *R. Drescher*. Zeitschr. d. deutsch. geol. Gesellsch., vol. xv, p. 341.
1864. — — — *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 19.

1870. *TEREDO AMPHISBÆNA*, *F. Römer*. Geol. v. Oberschles., pp. 317, 340, pl. xxxiv, figs. 14, 15.
- *GASTROCHÆNA AMPHISBÆNA*, *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, pp. 14, 29.
1873. — — *H. B. Geinitz*. Das Elbthalgeb. in Sachsen (Palæontographica, vol. xx, pt. 1), p. 235, pl. lii, figs. 8—12.
1876. — — *D. Brauns*. Zeitschr. f. d. gesammte Naturwiss., vol. xlvi, p. 358.
1877. — — *A. Fritsch*. Stud. im Gebiete der böhm. Kreideformat. ii, Weissenberg. u. Malnitz. Schicht., p. 122, fig. 93.
1888. — — *G. Müller*. Jahrb. d. k. preussisch. geol. Landesanst. für 1887, p. 436.
1889. — — *A. Fritsch*. Stud. im Gebiete der böhm. Kreideformat. iv, Teplitz. Schicht., p. 79, fig. 67.
- — *O. Griepenkerl*. Senon. v. Königslutter (Palæont. Abhandl., vol. iv), p. 69, (? pl. vii, fig. 1).
- ? 1889. ? — — *E. Holzappel*. Die Mollusk. Aachen. Kreide (Palæontographica, vol. xxxv), p. 143.
- ? 1893. — — *Fritsch*. Op. cit. v. Priesen. Schicht., p. 96, fig. 113.
- ? 1895. ? — — *F. Vogel*. Holländisch. Kreide, p. 49, pl. iii, fig. 13.
1897. — — *R. Leonhard*. Kreideformat. in Oberschles. (Palæontographica, xlv), p. 53, fig. 8.
1898. *TURNUS AMPHISBÆNA*, *G. Müller*. Mollusk. d. Untersenon v. Braunschweig u. Ilsede (Abhandl. d. k. preuss. geol. Landesanst., N. F., Heft 25), p. 79, pl. x, fig. 12.
1902. — — *A. Wollemand*. Fauna der Lüneburg. Kreide (Abhandl. d. k. preuss. geol. Landesanst. N. F., Heft 37), p. 81.

Description.—Tubes long, conical, tapering gradually, sometimes nearly straight, but usually bending or curving irregularly, circular in section, but often compressed, and then showing a median longitudinal furrow on one side. Diameter sometimes reaches 15 mm. and the length 210 mm. Surface with narrow transverse ridges at more or less regular intervals giving a segmented appearance; sometimes also with smaller growth-rings between the ridges.

Remarks.—This species ranges almost throughout the Chalk and is widely distributed. It has been referred by various authors to five different genera, but

its systematic position must still be regarded as uncertain, for although the tubes are common the valves have not been found in association with them. Fritsch (1893) and Müller (1898) have found the valves of *Turnus* in the same deposit as the tubes, and think it probable that the former belong to the same species as the latter. Some authors have referred these tubes to the genus *Gastrochæna*, but Stoliczka points out that they resemble more nearly the tubes of *Teredo*.

Types.—From the Senonian of Maestricht and Bochum. The specimens figured by Sowerby (except fig. 2, which is in the British Museum), by Mantell, and by Dixon cannot be found.

Distribution.—Chloritic Marl of Eastbourne. Cambridge Greensand. Chalk Marl of Chard and Ventnor. Zone of *Holaster subglobosus* of Holborough near Rochester, Totternhoe, Cherry Hinton, and Burwell. Zone of *Rhynchonella Cuvieri* of the Devon coast, Winchester, the Isle of Wight, and Lewes. Zone of *Terebratulina* of Winchester, the Isle of Wight, Croydon, and Devon. Zone of *Holaster planus* of the Dorset coast, the Isle of Wight, Dover, and Luton. Zone of *Micraster cor-testudinarium* of Mitcheldever, Dover, the Sussex coast, and Coulsdon (Surrey). Zone of *M. cor-anguinum* of the Sussex coast, St. Margaret's, Thanet, and Gravesend. Zone of *Marsupites testudinarius* of Highfield, near Salisbury, the Sussex coast, and Thanet. Zone of *Actinocamax quadratus* of the Sussex coast.

Family—TEREDINIDÆ, *Scacchi*.

Genus—TEREDO, *Linnaeus*, 1758.

(‘Syst. Nat.,’ ed. 10, p. 651; ed. 12, 1767, p. 1267.)

TEREDO GAULTINA, sp. nov. Plate XXXVIII, fig. 21.

Description.—Shell convex, inequilateral. Anterior gape large, angular. Postero-ventral gape small. Postero-dorsal margin produced upwards and outwards. Umbones large, incurved. A shallow furrow extends from the umbo to the ventral margin. Posterior to the furrow the shell is ornamented with ribs and narrow furrows, which soon bend dorsally, and disappear or become indistinct on the postero-dorsal part; in front of the furrow the ribs are much smaller, and are parallel to the margin of the anterior gape; at first they are directed dorsally, but soon bend forwards. Length, 9 mm.; breadth, 8.5 mm.

Affinities.—In *T. varennensis*, Buvignier,¹ the anterior ribs are coarser and the posterior end of the shell is more produced than in this species.

Distribution.—Gault of Folkestone.

¹ ‘Statist. géol. min. et paléont. de la Meuse,’ Atlas (1852), p. 6, pl. vi, figs. 40—48.

Family—ANATINIDÆ, Gray.*Genus*—PLECTOMYA, *P. de Loriol*, 1868.

(De Loriol and Cotteau, 'Mon. Paléont. Géol. Portlandien de l'Yonne,' p. 89.)

PLECTOMYA ANGLICA, sp. nov. Plate XXXIX, fig. 1*a*, *b*.

Description.—Shell elongate-oval, slightly inequilateral, compressed; anterior and posterior ends rounded; ventral margin slightly convex. Umbones broad, with a slight posterior curvature.

The part of the shell in front of a line drawn from the umbo to the opposite ventral margin is ornamented with strong concentric ribs separated by broad furrows; these ribs become nearly or quite obsolete on the posterior middle part of the shell (except near the umbo), but re-appear on the postero-dorsal part. The entire surface of the shell is ornamented with numerous radial rows of granules. Length 49 mm.; height 27 mm.

Affinities.—This species is similar in general character to *Plectomya Agassizi* (d'Orbigny¹), but the shell is less elongate, the ribs on the anterior part of the shell cut the margin and the growth-lines obliquely, and on the posterior median part the ribs are almost obsolete. It also shows some resemblance to *P. Rhodani* (Pictet and Roux²).

Remarks.—Of this species I have seen only two examples, neither of which shows the interior, so that I am unable to express an opinion as to affinities of the genus *Plectomya*.

Distribution.—Lower Greensand (Crackers) of Atherfield.³

Genus—ANATINA, *Lamarck*, 1809.

('Philosoph. Zool.,' vol. i, p. 319; 'Hist. nat. Anim. sans Vert.,' vol. v, 1818, p. 462.)

Sub-genus—CERCOMYA, *L. Agassiz*, 1842.

('Études crit. Moll. Foss.,' Myes, p. 143.)

¹ 'Pal. Franç. Terr. Crét.,' vol. iii (1845), p. 371, pl. cccxix, figs. 1, 2; Pictet and Campiche, 'Foss. Terr. Crét. Ste. Croix' ('Matér. Pal. Suisse,' ser. 4, 1865), p. 99, pl. cvii, fig. 1.

² 'Moll. Foss. Grès verts de Genève' (1852), p. 410, pl. xxix, fig. 4.

³ An imperfect specimen from the Lower Greensand of Atherfield is probably an example of *Plectomya marullensis* (d'Orbigny), op. cit., p. 376, pl. cccxxi, figs. 3, 4; Pictet and Campiche, op. cit., p. 101, pl. cvii, figs. 2, 3.

ANATINA (CERCOMYA) GURGITIS, *Pictet and Campiche*, 1865. Plate XXXIX, figs. 2—4.

1855. ANATINA ROBINALDINA, *F. J. Pictet and E. Renevier*. Foss. Terr. Aptien (Matér. Pal. Suisse, ser. 1), p. 63, pl. vii, fig. 1.
(Non *A. Robinaldina*, d'Orbigny, 1845.)
1865. — GURGITIS, *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 105, pl. cvii, figs. 6—8.
1870. — (CERCOMYA) GURGITIS, *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 74.

Description.—Shell elongate, compressed, inequilateral, highest in front of the umbones, tapering posteriorly. Anterior margin rounded. Umbones inconspicuous, with a carina extending to the posterior extremity. A very shallow sulcus passes from the umbo obliquely forwards across the valve. In front of this sulcus the ornamentation consists of narrow, sharp, concentric ribs separated by broad interspaces; both ribs and interspaces are crossed by numerous radial rows of very small pointed projections. Behind the sulcus the concentric ribs become less distinct or represented by growth-rings only.

Affinities.—This species is allied to *A. (Cercomya) Robinaldina*, d'Orbigny,¹ but the posterior part of the shell is more elongate.

Remarks.—I have seen only three examples of this species. Pictet and Campiche state that the part of the shell just in front of the carina is ornamented with radial rows of punctate striæ; these are not seen on the English specimens, probably on account of their somewhat imperfect preservation. One of our specimens (Plate XXXIX, fig. 3) agrees very closely, both in the form of the shell and in the character of the ornamentation, with the figure given by Pictet and Renevier; the others (figs. 2, 4) approach more nearly the examples figured by Pictet and Campiche, but the anterior part of the shell is rather higher.

Type.—From the Aptian of the Perte-du-Rhône.

Distribution.—Lower Greensand (Crackers) of Atherfield.

ANATINA (CERCOMYA), sp. Plate XXXIX, fig. 5*a, b*.

Description.—Shell very long, compressed, considerably inequilateral, highest in front of the umbones; posterior part tapering, and curved upwards. Anterior margin rounded; ventral margin convex; postero-dorsal margin concave. Umbones curved posteriorly, with a carina and a shallow furrow extending to the

¹ 'Pal. Franç. Terr. Crét.,' vol. iii (1845), p. 374, pl. ccclxx, figs. 6—8.

posterior extremity. On the anterior part of the shell the ornamentation consists of narrow, sharp, concentric ribs, which become less distinct on the median and posterior parts.

Remarks.—Only one specimen—an internal cast—has been seen. It resembles *A. (Cercomya) gurgitis*, but is more inequilateral and more elongate.

Distribution.—Upper Greensand of the Isle of Wight.

ANATINA (*CERCOMYA*), sp. Plate XXXIX, fig. 6.

Imperfect specimens of a species of *Anatina (Cercomya)* have been found in the Upper Greensand of Warminster and in the Cenomanian (Bed 10) of Dunscombe, South Devon. In shape they resemble *A. (Cercomya) producta*, Zittel.¹

Genus—THRACIA, *Leach* in *H. M. D. de Blainville*, 1824.

(‘*Dict. Sci. nat.*,’ vol. xxxii, p. 347.)

THRACIA PHILLIPSI, *Römer*, 1841. Plate XXXIX, figs. 7—9.

1829. MYA DEPRESSA, *J. Phillips*. *Geol. Yorks.*, p. 121, pl. ii, fig. 8 (non *M. depressa*, Sowerby, 1823).
1841. THRACIA PHILLIPSI, *F. A. Römer*. *Die Verstein. d. nord-deutsch. Kreidegeb.*, p. 74, pl. x, fig. 1.
1850. — RECURVA, *A. d'Orbigny*. *Prodr. de Pal.*, vol. ii, p. 117. (? *T. subdepressa*, p. 74.)
1854. — PHILLIPSI, *J. Morris*. *Cat. Brit. Foss.*, ed. 2, p. 227.
1865. — — *F. J. Pictet and G. Campiche*. *Foss. Terr. Crét. Ste. Croix* (Matér. Pal. Suisse, ser. 4), p. 120.
- — RECURVA, *Pictet and Campiche*. *Ibid.*, p. 120.
1870. — — *F. Stoliczka*. *Palæont. Indica, Cret. Fauna S. India*, vol. iii, p. 72 (*Corimya*?).
1875. — PHILLIPSI, *Phillips*. *Op. cit.*, ed. 3, p. 254, pl. ii, fig. 8.
1900. — PHILLIPSI, *A. Wolle mann*. *Die Biv. u. Gastrop. d. deutsch. u. holländ. Neocoms* (Abhandl. d. k. preussisch. geol. Land., n. F., pt. 31), p. 139, pl. vi, fig. 6.
1905. — — *E. Harbort*. *Die Fauna d. Schaumburg-Lippe'schen Kreidemulde* (ibid., pt. 45), p. 77.
1908. — — *Wolle mann*. *Jahrb. d. k. preuss. geol. Landesanst.*, für 1908, vol. xxix, p. 166.

Description.—Shell thin, more or less ovate in outline, moderately convex, the right valve a little more convex than the left, slightly inequilateral. Antero-dorsal

¹ ‘*Die Bivalv. d. Gosaugeb.*,’ pt. 1 (1864), p. 10 [114], pl. i, fig. 6.

margin nearly straight, with a considerable ventral slope; anterior margin rounded, passing gradually into the convex ventral margin; posterior margin rather short, oblique, more or less truncated, forming a rounded angle with the nearly straight and ventrally sloping postero-dorsal margin. Umbones rather prominent, curved inwards and slightly backwards. Postero-dorsal part of valves compressed, sometimes with a small carina. Surface with numerous small concentric growth-ridges.

Measurements:

		(1)		(2)		(3)
Length	.	68	.	64	.	49 mm.
Height	.	52	.	46	.	38 „
Thickness	.	30	.	28	.	22 „

(1—3) Speeton.

Affinities.—It is probable, as maintained by Harbort,¹ that *Thracia striata*, Weerth,² is not specifically distinct from *T. Phillipsi*.

Remarks.—The greater part of the shell has disappeared from most of the examples found at Speeton, and usually some part of the margin of the cast has also been lost. I have not seen sufficient examples to enable me to determine whether the variation of this species in England is as great as in the case of the specimens found in Schaumburg-Lippe and described by Harbort.

Type.—From Speeton, in the York Museum.

Distribution.—Speeton Clay (zone of *Belemnites jaculum*) of Speeton.

THRACIA ROTUNDATA (*Sowerby*), 1836. Plate XXXIX, fig. 10*a, b*.

1836. PANOPEA ROTUNDATA, *J. de C. Sowerby*. Trans. Geol. Soc., ser. 2, vol. iv, pp. 129, 337, pl. xiii, fig. 2.

1850. LYONSIA SUBROTUNDATA, *A. d'Orbigny*. Prodr. de Pal., vol. ii, p. 74.

1854. MYACITES ROTUNDATA, *J. Morris*. Cat. Brit. Foss., ed. 2, p. 214.

1865. THRACIA SUBROTUNDATA, *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 120.

1870. CORIMYA ROTUNDATA, *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 72.

Description.—Shell regularly convex, oval, slightly inequivalve and inequilateral. Anterior and ventral margins convex, forming a regular curve. Dorsal part of posterior margin oblique, forming an angle with the ventral part. Umbones broad, in contact, with a narrow, sharp, curved carina extending to the posterior angle and limiting a triangular, concave, postero-dorsal area, which is ornamented with fine ribs running parallel to the posterior margin. Sides of valves with similar ribs extending in a radial direction.

¹ 'Die Fauna d. Schaumburg-Lippe'schen Kreidemulde' (1905), p. 78.

² 'Neocomsandst. im Teutoburg. Walde' ('Palæont. Abhandl.' II, 1884), p. 40, pl. viii, fig. 10. Wollemaun, 'Die Bivalv. u. Gastrop. d. deutsch. u. holländ. Neocoms' (1900), p. 140, pl. vii, fig. 1.

Measurements:

	(1)	(2)
Length . . .	40	32 mm.
Height . . .	32	27 „
Thickness . . .	22	17 „

(1, 2) Lypne.

Affinities.—This species is allied to *T. rotunda*, Pictet and Roux,¹ from the Gault of the Perte-du-Rhône and Sainte Croix, but is distinguished by its more rounded outline, smaller postero-dorsal area, and less distinct concentric ornament. It is also allied to *T. carinifera* (p. 244).

Remarks.—Two internal casts of this species from Lypne are in the Museum of Practical Geology (23470, 23471); the larger agrees closely with Sowerby's figure, and may perhaps be the type, but the locality given by Sowerby is Court-at-Street, $1\frac{1}{4}$ miles west of Lypne. A small, somewhat crushed example from the Atherfield Clay at Dover colliery probably belongs to this species. No other specimens have been seen. The specimens recorded by Topley as *T. carinifera* probably belong to *T. rotundata*.

Distribution.—Hythe Beds of Lypne and Court-at-Street.²

THRACIA ROBINALDINA? (*d'Orbigny*), 1845. Plate XL, figs. 1—3.

Description.—Shell oval, nearly equilateral; right valve more convex than the left; posterior part not quite so high as the anterior part; postero-dorsal part compressed. Anterior margin rounded; ventral margin moderately convex; posterior margin slightly curved; postero-dorsal margin nearly straight. Umbones rather prominent, curved posteriorly. Surface smooth, except for growth-lines.

Measurements:

	(1)	(2)	(3)
Length . . .	36	26	15 mm.
Height . . .	23	17	9 „
Breadth . . .	13	10	6 „

(1) *Perna*-bed, (2, 3) Crackers, Atherfield.

Remarks.—In the English specimens, which are here provisionally referred to *T. Robinaldina*, the shell is preserved, but the examples of that species figured by *d'Orbigny*³ and by Pictet and Campiche⁴ are internal casts, and it is consequently

¹ 'Moll. Foss. Grès verts de Genève' (1852), p. 414, pl. xxix, fig. 6. Pictet and Campiche, 'Foss. Terr. Crét. Ste. Croix' ('Matér. Pal. Suisse,' ser. 4, 1865), p. 117.

² *Thracia Nicoleti* (Agassiz) has been recorded by Morris and by Topley from the Hythe Beds of Hythe, but I have not seen any British examples of that species.

³ 'Pal. Franç. Terr. Crét.,' vol. iii (1845), p. 380, pl. ccclxxii, figs. 1, 2.

⁴ 'Foss. Terr. Crét. Ste. Croix' ('Matér. Pal. Suisse,' ser. 4, 1865), p. 114, pl. cviii, figs. 5, 6.

difficult, especially without the opportunity of comparing specimens, to establish the identification. Professor Boule informs me that the type is a poorly preserved specimen, but that its outline is satisfactorily represented in d'Orbigny's figure; the specimen is now in the Natural History Museum, Paris. *T. Robinaldina* is allied to *T. neocomiensis* (d'Orbigny),¹ but is said to differ from the latter by the greater curvature of the ventral margin and by its relatively shorter shell.

Distribution.—Lower Greensand (*Perna*-bed and Crackers) of Atherfield. Atherfield Beds of Redhill, Reigate.

THRACIA SANCTÆ-CRUCIS, *Pictet and Campiche*, 1865. Plate XL, figs. 4—6.

1865. THRACIA SANCTÆ-CRUCIS, *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 117, pl. cviii, fig. 8.

1870. — — — *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 72.

Description.—Shell oblong, compressed, inequilateral. Anterior margin rounded; ventral margin slightly curved; posterior margin truncated, slightly convex, forming an angle with the postero-dorsal margin. A carina extends in a curve from the umbo to the postero-ventral angle and cuts off a concave postero-dorsal area. The surface of the shell is ornamented with growth-rings.

Measurements:

		(1)	(2)
Length	. .	43	. 39 mm.
Height	. .	20	. 16 „

(1) Gault, Folkestone.

(2) Gault, Black Ven.

Affinities.—It seems doubtful whether this species is distinct from *T. simplex* (d'Orbigny), of which casts only are figured by d'Orbigny² and by Pictet and Campiche³; but the latter authors state that it differs from *T. simplex* by the absence of an internal rib, the presence of a carina, and by the more acuminate anterior end.

Type.—From the Upper Gault of Ste. Croix.

Distribution.—Gault of Folkestone and Black Ven.

THRACIA, sp. Plate XL, figs. 7—9.

Some examples of *Thracia*, usually of rather large size, appear at first sight to be distinct from *T. Sanctæ-Crucis* on account of their relatively greater height and

¹ 'Pal. Franç. Terr. Crét.,' vol. iii (1845), p. 381, pl. cclxxii, figs. 3, 4. Pictet and Campiche, op. cit., p. 115, pl. cviii, figs. 3, 4.

² Op. cit., p. 382, pl. cclxxii, figs. 5, 6.

³ 'Foss. Terr. Crét. Ste. Croix' ('Matér. Pal. Suisse,' ser. 4, 1865), p. 116, pl. cviii, fig. 7.

less distinct carina. When, however, a considerable number of specimens are compared it is difficult to draw any line of separation between these forms and *T. Sanctæ-Crucis*. But since, in most cases, the original shape of the shell has been more or less considerably modified by pressure, it is not easy to come to a definite conclusion in this matter; moreover, in both *T. Sanctæ-Crucis* and the larger forms there is clearly some variation in relative height and length of the shells, and in the distinctness of the carina.¹

Distribution.—Gault of Black Ven and Folkestone. Upper Greensand of Blackdown and Devizes.

THRACIA CARINIFERA (*Sowerby*), 1826. Plate XL, figs. 10—13.

1826. LUTRARIA ? CARINIFERA, *J. de C. Sowerby*. Min. Conch., vol. vi, p. 66, pl. dxxxiv, fig. 2.
1832. — — — *A. Passy*. Descript. géol. de la Seine-Infér., Atlas, p. 6, pl. xiii, figs. 6, 7.
1842. CORIMYA CARINIFERA, *L. Agassiz*. Études crit. Moll. Foss., Myes, p. 264.
1845. LYONSIA CARINIFERA, *A. d'Orbigny*. Pal. Franç. Terr. Crét., vol. iii, p. 385, pl. ccclxxiii, figs. 1, 2.
1850. — — — *A. d'Orbigny*. Prodr. de Pal., vol. ii, p. 158.
1852. — — — *R. Kner*. Denkschr. d. k. Akad. d. Wissensch. Wien, Math.-nat. Cl., vol. iii, p. 311.
1854. LUTRARIA CARINIFERA, *J. Morris*. Cat. Brit. Foss., ed. 2, p. 208 (? *Thracia*).
1865. THRACIA CARINIFERA, *F. J. Pietet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 121.
1870. — — — *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 72.
1893. LYONSIA CARINIFERA, *A. Fritsch*. Stud. im Gebiete der böhm. Kreideformat. v. Priesen. Schicht., p. 97, fig. 115.

Description.—Shell thin, oval, of moderate convexity, slightly inequivalve and inequilateral. Anterior margin rounded, passing gradually into the regularly convex ventral margin. Posterior margin truncated, straight or slightly concave. Postero-dorsal margin nearly straight. Umbones broad, incurved close together, with a sharp carina passing to the postero-ventral angle and limiting a flattened or slightly concave postero-dorsal area, which is divided in the middle by a shallow, longitudinal furrow. Just in front of the carina is a broad, shallow, concave depression.

Ornamentation consists of broad, slightly raised, concentric folds which are more distinct on the anterior part than elsewhere. On the postero-dorsal area are

¹ A similar case of distortion and variation is furnished by *Thracia semiplanata*, Whiteaves, 'Mesozoic Foss.' ('Geol. Surv. Canada'), vol. i (1884), p. 221, pl. xxix, fig. 5.

numerous, fine, regular ribs parallel with the posterior margin; on the remainder of the shell similar ribs, but running in a radial direction, occur.

Measurements:

	(1)	(2)	(3)	(4)
Length . . .	37	33	30	20 mm.
Height . . .	23	22	21	14 „
Thickness . .	15	14	—	10 „

(1) Chalk Marl, Chard.

(2, 4) Chloritic Marl, Devizes.

(3) Chalk Marl, Ventnor.

Affinities.—In this species the shell is more elongate and less convex, the carina more prominent, and the postero-dorsal area larger than in *T. rotundata* (p. 241). *T. carinifera* is closely allied to *T. elegans* (d'Orbigny),¹ from the Cenomanian of St. Sauveur, but is less elongate. *T. Germari* (Geinitz)² from the Senonian, is regarded by Brauns³ as a synonym of *T. carinifera*; but without seeing specimens of the former it is difficult to express an opinion of its relationship.

Remarks.—The specimens vary considerably in the proportion of length to height, but in some cases the differences are probably due partly to crushing. The shell itself is seldom preserved.

Type.—The type came from the Cenomanian of Dowlands (South Devon) and was originally in the collection of Sir H. T. De la Beche, but cannot now be found.

Distribution.—Chloritic Marl of Devizes and Maiden Bradley. Chalk Marl of Ventnor, Evershot, and Chard.

Family—PHOLADOMYIDÆ, *Gray*.

Genus—PHOLADOMYA, *G. B. Sowerby*, 1825.

(‘Genera Rec. and Foss. Shells,’ no. xix, pl. xxxvii.)

PHOLADOMYA CORNUELIANA (*d'Orbigny*), 1844. Plate XLI, figs. 2*a*, *b*, 3.

1844. CARDIUM CORNUELIANUM, *A. d'Orbigny*. Pal. Franç. Terr. Crét., vol. iii, p. 23, pl. cclvi, figs. 1, 2.

1845. — — — *E. Forbes*. Quart. Journ. Geol. Soc., vol. i, p. 243.

1850. PHOLADOMYA CORNUELIANA, *A. d'Orbigny*. Prodr. de Pal., vol. ii, p. 117.

1854. CARDIUM CORNUELIANUM, *J. Morris*. Cat. Brit. Foss., ed. 2, p. 192.

¹ ‘Pal. Franç. Terr. Crét.,’ vol. iii (1845), p. 386, pl. ccclxxiii, figs. 3—5.

² ‘Quadersandst. oder Kreidegeb. in Deutschland’ (1850), p. 150, pl. x, figs. 9—11.

³ ‘Senon. Mergel d. Salzberges,’ Zeitschr. f. d. gesammt. Naturwiss., vol. xlvi (1876), p. 359, pl. x, figs. 18, 19.

1855.	PHOLADOMYA CORNUELIANA,	<i>F. J. Pictet and E. Renevier.</i>	Foss. Terr. Aptien (Matér. Pal. Suisse, ser. 1), p. 59, pl. vi, fig. 6.
1865.	—	—	<i>F. J. Pictet and G. Campiche.</i> Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 87.
—	—	—	<i>H. Coquand.</i> Aptien de l'Espagne, p. 93.
1870.	—	—	<i>F. Stoliczka.</i> Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 75.
1875.	—	—	<i>G. Moesch.</i> Mon. Pholadomyen, p. 96, pl. xxxiii, fig. 8 (? pl. xxxvi, fig. 4).

Description.—Shell small, short, oval, inflated, compressed posteriorly, moderately inequilateral with a small gape at the posterior end. Margins rounded. Umbones prominent, incurved.

Ornamentation consists of strong, rounded, radial ribs. The grooves between the ribs are shallow, and broader than the ribs. Concentric ribs cross the grooves and ribs, giving to the latter a granulate or tuberculate appearance. Near the posterior and anterior margins radial ribs are absent.

Measurements :

		(1)	(2)
Length	.	20	13 mm.
Height	.	16	10 „

(1, 2) Atherfield.

Affinities.—This species resembles *P. Sancti-Sabæ* (Römer)¹ from Texas and *P. Vignesi*, Lartet,² from Palestine, Syria, and Zululand, and *P. subdinensis* (d'Orbigny),³ from the Cenomanian of Le Mans.

Type.—From the Aptian of Wassy (Haute-Marne).

Distribution.—Lower Greensand (Crackers) of Atherfield. Recorded by Topley from the Atherfield Beds of Peasemarsch and Shalford.

PHOLADOMYA GIGANTEA (*Sowerby*), 1836. Plate XL, fig. 14; Plate XLI, fig. 1.

1708. *C. N. Lang*, Hist. lapidum figuratorum, p. 146, pl. xlv, fig. 1.

1718. *J. J. Scheuchzer*, Helvetiæ hist. nat., pt. 3, p. 307, fig. 113.

1742. *L. Bourguet*, Traité des Petrific., pl. xxiv, fig. 145.

¹ 'Kreidebild. v. Texas' (1852), p. 48, pl. vi, fig. 7. *P. Cornueliana* has been compared with *Corbula æquivalvis*, Goldfuss, by Pictet and Renevier, Pictet and Campiche, and Moesch, but Holzapfel has shown that Goldfuss' species belongs to the genus *Liopistha*. Holzapfel, 'Die Mollusk. Aachen. Kreide' ('Palæontographica,' vol. xxxv, 1889), p. 150, pl. ix, figs. 4—6; Müller, 'Mollusk. d. Untersenon v. Braunschweig u. Ilsede' (1898), p. 76, pl. x, fig. 9.

² 'Explor. géol. de la Mer Morte' (1877), p. 126, pl. xi, fig. 9; Blanckenhorn, 'Beitr. z. Geol. Syriens' (1890), p. 94, pl. v, figs. 14—17; Kossmat, 'Denkschr. d. k. Akad. Wiss., Wien,' vol. lxxi (1902), p. 55, pl. iv, fig. 9; Newton, 'Trans. Roy. Soc. S. Africa,' vol. i (1909), p. 79, pl. vi, figs. 3—6.

³ 'Pal. Franç. Terr. Crét.,' vol. iii (1844), p. 38, pl. ccl, figs. 1—3. An internal cast resembling *P. subdinensis* has been found by Mr. J. Seanes in the Chloritic Marl of Maiden Bradley.

1836. PHOLAS GIGANTEUS, *J. de C. Sowerby*. Trans. Geol. Soc., ser. 2, vol. iv, pp. 130, 338, pl. xvi, fig. 1.
1840. PHOLADOMYA ELONGATA, *A. Goldfuss*. Petref. Germ., vol. ii, p. 270, pl. clvii, fig. 3.
1842. — — *L. Agassiz*. Études crit. Moll. Foss., Myes, p. 57, pl. i, figs. 16, 17.
- — *SCHEUCHZERI, Agassiz*. Ibid., p. 58, pl. ii¹, figs. 3—7, pl. ii¹¹, fig. 7.
- — *FAVRINA, Agassiz*. Ibid., p. 59, pl. ii¹, figs. 1, 2.
- — *LANGII, Voltz, in Leymerie*. Mém. Soc. géol. de France, ser. 2, vol. v, p. 24.
1845. — *ELONGATA, A. d'Orbigny*. Pal. Franc. Terr. Crét., vol. iii, p. 350, pl. cccxii.
- *GIGANTEA, E. Forbes*. Quart. Journ. Geol. Soc., vol. i, p. 238.
1850. — *ELONGATA, d'Orbigny*. Prodr. de Pal., vol. ii, p. 73.
1852. — *FAVRINA, F. J. Pictet and W. Roux*. Moll. Foss. Grès verts de Genève, pp. 403, 546, pl. xxix, fig. 1.
1854. — *GIGANTEA, J. Morris*. Cat. Brit. Foss., ed. 2, p. 220.
1855. — *ELONGATA, G. Cotteau*. Moll. Foss. de l'Yonne, p. 55.
- — *F. J. Pictet and E. Renevier*. Foss. Terr. Aptien (Matér. Pal. Suisse, ser. 1), p. 61.
1858. — — *J. Vilanova-y-Piera*. Mem. geog.-agric. de Castellon, pl. iii, fig. 16.
1861. — — *P. de Loriol*. Anim. Invert. Foss. Mt. Salève, p. 56.
- 1864—65. — — *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 74, pl. civ, figs. 1—4.
1870. — *GIGANTEA et ELONGATA, F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 74.
1875. — *GIGANTEA, C. Moesch*. Mon. Pholadomyen, p. 82, pl. xxx, fig. 6; pl. xxxi, figs. 2—4.
1884. — cf. *GIGANTEA, O. Weerth*. Die Fauna des Neocom. im Teutoburg. Walde (Palæont. Abhandl., vol. ii), p. 34, pl. viii, figs. 2, 3.
1895. — *WEERTHII, F. Vogel*. Holländisch. Kreide, p. 59.
- — *ELONGATA, G. Maas*. Zeitschr. d. deutsch. geol. Gesellsch., vol. xlvii, p. 279, pl. ix, figs. 1, 2.
1896. — — *A. Wollemand*. Ibid., vol. xlviii, p. 850.
1900. — — *A. Wollemand*. Die Biv. u. Gastrop. d. deutsch. u. holländ. Neocoms (Abhandl. d. k. preussisch. geol. Land., N. F., pt. 31), p. 133.
- — *G. Müller*. Deutsch-Ost-Afrika, vol. vii, p. 557, pl. xxi, fig. 1.
1903. — — *C. Burckhardt*. Palæontographica, vol. 1, p. 76, pl. xv, figs. 1, 2.
1908. — — *A. Stojanoff*. Ann. géol. et min. de la Russie, vol. x, p. 116.

Description.—Shell large, elongate, somewhat arched, convex, but with the sides of the posterior part more or less flattened, very inequilateral, with a large gape at the posterior end. Anterior part short, with a rounded margin. Ventral margin curved. Posterior margin subtruncate, rounded. Postero-dorsal margin long, slightly concave or almost straight. Umbones broad. Near the umbones the antero-dorsal and postero-dorsal marginal parts of the shell are depressed.

Ornamentation consists of numerous narrow, sharp, prominent and sometimes slightly serrate radial ribs, which are straight or slightly curved. Near the anterior and the postero-dorsal margins ribs are absent; on the postero-dorsal part of the shell they are rather more widely separated and rather more prominent than on the median part. Between the ribs are broad, concave furrows which are crossed by numerous growth-lines.

Measurements :

	(1)	(2)
Length	126	122 mm.
Height	63	60 „

(1, 2) Crackers, Atherfield.

Affinities.—The elongate form and numerous sharp ribs distinguish this from other Cretaceous species of *Pholadomya*.

Remarks.—The foreign examples of this species show considerable variation in length, in the curvature of the shell, and in the number of ribs. Some of the varieties have been described as distinct species, but Pictet and Campiche have shown that there are numerous transitions between the different varieties. The English examples agree in most cases with the type of the species, but some approach the variety described by Agassiz as *P. Scheuchzeri*. A specimen figured by Moesch shows the large pallial sinus.

Type.—The type came from the Hythe Beds of Court-at-Street, but cannot now be found.

Distribution.—Lower Greensand (Crackers) of Atherfield. Atherfield Beds of East Shalford. Hythe Beds of Court-at-Street and Lympne.

PHOLADOMYA SPEETONENSIS, sp. nov. Plate XLI, fig. 4*a, b*.

Description.—Shell large, oval, short, inflated, very inequilateral. Anterior margin rounded; ventral margin convex. Umbones broad, incurved.

Ornamentation consists of numerous (usually about twenty-one) strong, radial ribs, separated by broad, slightly concave interspaces. Secondary ribs are introduced at a short distance from the umbo, and usually soon become as large as the primary ribs. The ribs are more or less nodular. Concentric growth-lines are present. Two or three of the anterior ribs are more widely separated than the others. On the postero-dorsal and the anterior parts of the shell ribs are absent.

Affinities.—By some authors this species has been identified with *P. Martini*, Forbes. With the material at present available it is difficult to make a satisfactory comparison; but the specimens from Speeton are of considerably larger size, with broader and less prominent umbones, and with the posterior part of the shell less compressed than in *P. Martini*.

In form this species resembles *P. alternans*, Römer,¹ but the umbones are relatively higher, and the radial ribs more numerous. The ribs are not so numerous as in *P. Eberti*, Wollemaun.²

Remarks.—The specimens from the clays are considerably crushed, whilst in those from the hard nodular beds a more or less considerable portion of the marginal part of the shell is missing.

Distribution.—Speeton Clay (zones of *Belemnites lateralis*, *B. jaculum*, and *B. brunsvicensis*) of Speeton.

PHOLADOMYA MARTINI, *Forbes*, 1845. Plate XLI, fig. 5.

1845.	PHOLADOMYA MARTINI,	<i>E. Forbes.</i>	Quart. Journ. Geol. Soc., vol. i, p. 238, pl. ii, fig. 3.
1850.	—	—	<i>A. d'Orbigny.</i> Prodr. de Pal., vol. ii, p. 117.
1854.	—	—	<i>J. Morris.</i> Cat. Brit. Foss., ed. 2, p. 220.
1865.	—	—	<i>F. J. Pictet and G. Campiche.</i> Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 92.
? 1908.	—	—	<i>A. Wollemaun.</i> Jahrb. d. k. preuss. geol. Landes- anst. für 1908, vol. xxix, p. 165, pl. x, fig. 3.

Description.—Shell rather small, oval, very inequilateral, anterior part inflated, posterior part compressed. Umbones prominent. Escutcheon deep. Ornamentation consists of numerous radial ribs, which are more or less tuberculate, and are more widely separated anteriorly than on the median part; on the anterior and postero-dorsal parts ribs are indistinct or absent. Concentric ribs and growth-lines are present.

Remarks.—It is difficult to give a satisfactory description of this species, since the specimens seen are few in number, imperfectly preserved, and usually crushed. *P. Martini* appears to be closely allied to *P. Fabrina*, d'Orbigny (see below). It also resembles *P. hispanica*, Coquand.³

¹ Wollemaun, 'Die Biv. u. Gastrop. d. deutsch. u. holländisch. Neocoms' (1900), p. 134, pl. v, figs. 9, 10; pl. vi, fig. 3. Specimens with fewer ribs from the Spilsby Sandstone and the Claxby Ironstone of Lincolnshire approach *P. alternans* more nearly than do the specimens from Speeton.

² Ibid., p. 136, pl. vi, fig. 4.

³ 'Mon. Aptien de l'Espagne' (1865), p. 92, pl. vii, figs. 5, 6.

Type.—From the Hythe Beds of Pulborough. A specimen which is believed to be the type, but which is more crushed dorso-ventrally than is indicated by the figure, is in the Museum of the Geological Society (No. 2197).

Distribution.—Lower Greensand (*Perna*-bed and Crackers) of Atherfield. Hythe Beds of Pulborough.

PHOLADOMYA FABRINA, *d'Orbigny*, 1845. Plate XLI, fig. 6.

1845. PHOLADOMYA FABRINA, *A. d'Orbigny*. Pal. Franç. Terr. Crét., vol. iii, p. 354, pl. cclxiii, figs. 6, 7. (Non *P. Favrina*, Agassiz, Pictet and Roux.)
1850. — — *d'Orbigny*. Prodr. de Pal., vol. ii, p. 135.
1865. — — *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 92.
1897. — *FAVRINA*?, *R. B. Newton*. Proc. Dorset Nat. Hist. and Antiq. Field Club, vol. xviii, p. 92.
- ? Non 1874. — *FABRINA, C. Moesch*. Mon. Pholadomyen, p. 94, pl. xxxii, fig. 1.

Remarks.—Some crushed specimens found in the Gault are probably examples of *P. Fabrina*, *d'Orbigny*. They resemble *P. Martini*, but have coarser and more distinctly tuberculate ribs, and the concentric rings appear to be more conspicuous.

Distribution.—Gault of Black Ven, Okeford Fitzpaine, and Folkestone.

PHOLADOMYA DECUSSATA (*Mantell*), 1822. Plate XLI, figs. 7—9; Plate XLII, fig. 1.

1822. CARDIUM? DECUSSATUM, *G. Mantell*. Foss. S. Downs, p. 126, pl. xxv, fig. 3.
1827. — — *J. de C. Sowerby*. Min. Conch., vol. vi, p. 99, pl. dlvi, fig. 1.
1837. — — *A. Goldfuss*. Petref. Germ., vol. ii, p. 222, pl. cxlv, fig. 2.
- PHOLADOMYA DECUSSATA, *G. G. Pusch*. Polens Paläont., p. 87.
1841. CARDIUM DECUSSATUM, *F. A. Römer*. Die Verstein. d. nord-deutsch. Kreidegeb., p. 71.
1846. PHOLADOMYA DECUSSATA, *A. E. Reuss*. Die Verstein. der böhm. Kreideformat., pt. 2, p. 17.
1850. — — *J. de C. Sowerby*, in *F. Dixon*. Geol. Sussex, p. 355 (p. 385, ed. 2), pl. xxix, fig. 6.
- — *H. B. Geinitz*. Das Quadersandst. oder Kreidegeb. in Deutschland, p. 146.
- *R. Kner*. Verstein. d. Kreidemergels v. Lemberg (Haidinger's Naturwiss. Abhandl., vol. iii, pt. 2), p. 24.

1850. PHOLADOMYA DECUSSATA, *A. Alth.* Geogn.-palæont. Beschreib. v. Lemberg (ibid.), p. 236.
1854. — — — *J. Morris.* Cat. Brit. Foss., ed. 2, p. 220.
1861. — — — *var. TRIANGULARIS, H. G. Seeley.* Ann. Mag. Nat. Hist., ser. 3, vol. vii, p. 122.
1863. — (CARDIUM) DECUSSATA, *A. v. Strombeck.* Zeitschr. der deutsch. geol. Gesellsch., vol. xv, p. 143.
1865. — DECUSSATA, *F. J. Pictet and G. Campiche.* Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 94.
1869. — — — *E. Favre.* Moll. Foss. de la Craie de Lemberg, p. 106.
1875. — — — *A. J. Jukes-Browne.* Quart. Journ. Geol. Soc., vol. xxxi, p. 300.
- — — *C. Moesch.* Mon. Pholadomyen, p. 107, pl. xxxii, figs. 5 ?, 6 ; pl. xxxvi, figs. 5, 6.
1876. — — — *D. Brauns.* Zeitschr. f. d. gesammt. Naturwiss., vol. xlvi, p. 361.
- ? 1889. — — — *E. Holzapfel.* Die Mollusk. Aachen. Kreide (Palæontographica, vol. xxxv), p. 154, pl. xiv, figs. 3, 4.
1891. — — — *J. Böhm.* Kreidebildung. d. Fürbergs u. Sulzbergs (Palæontographica, vol. xxxviii), p. 73.
1893. — — — *A. Fritsch.* Stud. im Gebiete der böhm. Kreideformat. v. Priesen. Schicht., p. 97, fig. 116.
- ? 1898. — — — *G. Müller.* Mollusk. d. Untersen. v. Braunschweig u. Ilsede, p. 74, pl. x, fig. 3.
1901. — — — *A. Wollemaun.* Jahrb. d. k. preuss. geol. Landesanst. für 1900, vol. xxi, p. 22.
1902. — — — *A. Wollemaun.* Lüneburg. Kreide, p. 79.
- Non 1829. — — — *J. Phillips.* Geol. Yorks., pp. 122, 186 (p. 255, ed. 3), pl. ii, fig. 9.
- 1842. — — — *L. Agassiz.* Études crit. Moll. Foss., Myes, p. 74, pl. iv, figs. 9, 10 ; pl. iv¹, figs. 7—11.
- 1843—50. — — — *G. P. Deshayes.* Traité Élément. de Conchyliol., vol. i, pt. 2, p. 158, pl. v, fig. 5.
- 1849. — — — *A. d'Orbigny.* Prodr. de Pal., vol. i, p. 335.

Distribution.—Shell large, inflated, with the greatest diameter at the anterior end, outline semi-ovate (sometimes sub-trigonal), wedge-shaped behind, extremely inequilateral, with a small posterior gape; height and length often nearly equal. Ventral margin slightly curved. Posterior margin rounded. Anterior part of the shell very short, flattened, with cordate outline, nearly perpendicular to the plane between the valves, and forming almost a right angle with the sides of the valves; the margin of the anterior part is more or less angular, and just within is a shallow concave part parallel to the margin, whilst the median part is convex, and

that near the umbones is depressed. Umbones curved considerably inwards and more or less forwards. Escutcheon depressed.

Ornamentation consists of narrow radial ribs separated by broad, shallow depressions. Ribs are absent from the posterior part of the shell, and from the anterior flattened part, except near its margin; they become smaller or disappear altogether near the ventral margin. Well-marked growth-rings occur over the entire surface of the shell, but are more distinct near the umbones than ventrally, and give a granular or nodular appearance to the radial ribs, especially on the dorsal part of the shell.

Measurements:

	(1)	(2)	(3)
Length . . .	98	60	54 mm.
Height . . .	74	59	52 „
Thickness . . .	65	51	49 „

(1, 2) Chalk Marl, Ventnor.

(3) Chalk Marl, Eastbourne.

Affinities.—The smaller forms of this species show some resemblance to *P. genevensis*, Pictet and Roux,¹ from the Gault, but the concentric rings are less prominent, and the valves more inflated and less distinctly triangular. Another similar form is *P. Malbosi*, Pictet.² See also *P. cordata* (below).

The specimens from the Cambridge Greensand were regarded by Seeley as constituting a variety (*P. decussata* var. *triangularis*), but, as was pointed out by Jukes-Browne, they agree in all essential characters with *P. decussata*, differing only in their smaller size. Specimens of *P. decussata* found in the Gault of Folkestone are larger than those found in the Cambridge Greensand, but not so large as the examples in the Chalk.

Remarks.—In England this species has not been found above the Cenomanian (zone of *H. subglobosus*), but on the Continent it appears to range up into the Senonian. In many of the English specimens the original shape has been modified by crushing, and that also appears to be the case with some of the examples figured by foreign authors.

Type.—The type from the Lower Chalk near Brighton, and the specimen figured by Sowerby from the Chalk Marl of Hamsey, and the one figured by Dixon, cannot now be found.

Distribution.—Gault of Folkestone. Cambridge Greensand. Chalk Marl of Ventnor, Culver Cliff, Eastbourne, Hamsey, Middleham, Offham, Glynde and Folkestone. Totternhoe Stone (zone of *Holaster subglobosus*) of Arlesey and Burwell.

¹ 'Moll. Foss. Grès verts de Genève' (1852), p. 405, pl. xxix, fig. 2. Moesch, 'Mon. Pholadomyen' (1875), p. 97, pl. xxxii, figs. 2—4.

² 'Mélanges Paléont.' (1868), p. 92, pl. xix, fig. 3. Moesch, op. cit., p. 88, pl. xxx, fig. 5, pl. xxxv, fig. 1.

PHOLADOMYA CORDATA, *Tate*, 1865. Plate XLII, fig. 2 *a—c*.

1865. PHOLADOMYA CORDATA, *R. Tate*. Quart. Journ. Geol. Soc., vol. xxi, p. 40, pl. iv, fig. 1.

Remarks.—A specimen found in the Upper Chalk (zone of *Belemnitella mucronata*), now in the Norwich Museum (No. 3339), is probably an example of *P. cordata*, but unfortunately the anterior part of the shell is imperfect. In this species the anterior curvature of the umbones is greater and the depression in front of them deeper than in *P. decussata*; also the anterior flattened part is relatively smaller, since the greatest diameter of the shell occurs at about one third of the length from the anterior end. The types of *P. cordata* from the Upper Chalk of Ireland are in the Museum of Practical Geology (Nos. 23,628; 23,629).

Genus—MYOPHOLAS, *H. Douvillé*, 1907.

(‘Bull. Soc. géol. de France,’ ser. 4, vol. vii, p. 107.)

MYOPHOLAS, sp. *cf.* SEMICOSTATA (*Agassiz*), 1842. Plate XLII, fig. 3 *a, b*.

Description.—Shell oval, short, considerably inequilateral, anterior part convex, posterior part compressed; anterior and posterior margins rounded. Umbones curved inwards and forwards. Rather more than half of the shell—the anterior part—is ornamented with thirteen narrow, sharp, radial ribs, which are separated by broad, flat, or slightly concave interspaces; posteriorly these ribs become smaller and less widely separated; on the middle part of the shell a few indistinct concentric ribs are seen. The posterior part of the shell is nearly smooth, and is separated from the ribbed area by a slight depression; a curved carina extends from the posterior side of the umbo towards the postero-ventral extremity.

Affinities.—Only one specimen has been seen; it resembles closely *M. semicostata* (*Agassiz*¹), but is rather shorter, and the posterior limit of the ribbed area is more sharply defined than in most examples of *M. semicostata*. Judging from

¹ ‘Etudes crit. Moll. Foss.,’ *Myes* (1842), p. 51, pl. ii, figs. 1, 2, pl. iii¹, fig. 11. *Pictet* and *Campiche*, ‘Foss. Terr. Crét. Ste. Croix’ (‘Matér. Pal. Suisse,’ ser. 4, 1865), p. 77, pl. cv, figs. 1, 2. *Moesch*, ‘Mon. Pholadomyen’ (1874), p. 85, pl. xxx, fig. 4, pl. xxxiii, figs. 3, 4, pl. xxxvi, fig. 1. *Douvillé*, ‘Bull. Soc. géol. de France,’ ser. 4, vol. vii (1907), p. 112, pl. ii, fig. 8. *Moesch* includes as a synonym *Pholadomya Triboleti*, *Pictet* and *Campiche*, op. cit., p. 89, pl. cvi, fig. 8. *Pictet* and *Campiche* include *P. Moreana*, *Buvignier*, ‘Statist. géol., etc., de la Meuse’ (1852), Atlas, p. 8, pl. viii, figs. 21, 22.

the figures given by several authors, that species varies considerably, so that it seems probable that when more English specimens have been obtained it will be possible to refer them definitely to *M. semicostata*.

Distribution.—Lower Greensand of Furze Hill, Faringdon.

Genus—GONIOMYA, *L. Agassiz*, 1842.

(‘*Etudes crit. Moll. Foss.*,’ *Myes*, pp. xii, 1.)

GONIOMYA ARCHIACI (*Pictet and Renevier*), 1855. Plate XLII, figs. 4, 5.

1855–6. THRACIA ARCHIACI, *F. J. Pictet and E. Renevier*. *Foss. Terr. Aptien*
(*Matér. Pal. Suisse*, ser. 1), p. 67,
pl. vii, fig. 5.

1858. — — — *Pictet and Renevier*. *Ibid.*, p. 176.

1865. PHOLADOMYA THRACIOIDES, *F. J. Pictet and G. Campiche*. *Terr. Crét. Ste.*
Croix (*Matér. Pal. Suisse*, ser.
4), p. 92 (*Goniomya*).

1870. GONIOMYA ARCHIACI, *F. Stoliczka*. *Palæont. Indica, Cret. Fauna S. India*,
vol. iii, p. 75.

Description.—Shell oblong, convex, nearly equilateral. Anterior margin rounded. Ventral margin slightly convex or nearly straight, nearly parallel with the dorsal margin. Posterior margin truncated, oblique, slightly convex, forming a rounded angle with the ventral margin and an obtuse angle with the postero-dorsal margin. Umbones of moderate size, with a faint rounded carina extending postero-ventrally, above which the shell is compressed; lunule and escutcheon elongate, depressed, limited by carinæ.

Ornamentation: Anteriorly to the umbones there is a ribbed area in which the ribs extend obliquely backwards; posteriorly to the umbones is another ribbed area in which the ribs are nearly perpendicular to the postero-dorsal margin, but slightly curved ventrally. The anterior, ventral, and postero-dorsal parts of the shell are without ribs, and show growth-lines only. Near the umbo the ribs of the two areas are connected by horizontal ribs, but ventrally these horizontal ribs are absent or indistinct. Some parts of the shell are marked by rows of small pits.

Measurements:

	(1)	(2)	(3)
Length	33	28	19 mm.
Height	19	16	11 „

(1–3) Crackers, Atherfield.

Affinities.—This species is less inequilateral, and the ribs are less extensively developed than in *G. caudata*, Agassiz.¹

Remarks.—English examples of this species were identified by Pictet and Renevier, who state that the forms referred by Forbes² to *Pholadomya Agassizi* are really specimens of *G. Archiaci*.

Type.—From the Aptian of the Perte-du-Rhône.

Distribution.—Lower Greensand (Crackers) of Atherfield.³

GONIOMYA MAILLEANA (*d'Orbigny*), 1845. Plate XLII, figs. 6, 7.

1845. PHOLADOMYA MAILLEANA, *A. d'Orbigny*. Pal. Franç. Terr. Crét., vol. iii, p. 355, pl. cccxiv, figs. 1, 2.
1845. GONIOMYA MAILLEANA, *L. Agassiz*. Études. crit. Moll. Foss., Myes, p. xiv.
1850. PHOLADOMIA MAILLEANA, *A. d'Orbigny*. Prodr. de Pal., vol. ii, p. 157.
1854. PHOLADOMYA MAILLEANA, *J. Morris*. Cat. Brit. Foss., ed. 2, p. 220.
1865. — — *F. J. Pictet and G. Campiche*. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 93 (*Goniomya*).
- ? 1868. PHOLADOMYA MAILLEANA, *A. Briart and F. L. Cornet*. Meule de Bracquignies (Mém. cour. et Mém. des Sav. étrangers, vol. xxxiv), p. 83, pl. vi, fig. 12.
1870. GONIOMYA MAILLEANA, *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 75.
- ? 1885. PHOLADOMYA (GONIOMYA) MAILLEANA, *F. Nütling*. Die Fauna d. baltisch. Cenoman. (Palæont. Abhandl., vol. ii), p. 36, pl. vi, fig. 9.

Description.—Shell elongate, subquadrate, convex, very inequilateral. Anterior part not so high as the posterior part, compressed, with rounded margin. Antero-dorsal margin concave. Postero-dorsal margin long, nearly straight, and nearly parallel to the slightly convex ventral margin. Posterior margin truncated, oblique, forming a rounded angle with the ventral margin, and an obtuse angle with the postero-dorsal margin. Umbones pointed, directed anteriorly. Lunule concave, elongate-ovate, limited by a carina. Escutcheon long, deep near the umbones, limited by a carina. Between the carina of the escutcheon and a rounded ridge extending from the umbo towards the postero-ventral margin the shell is concave.

¹ 'Études crit. Moll. Foss.,' Myes (1842), p. 22, pl. 1b, figs. 1—3, pl. i, fig. 1. *Pholadomya Agassizi*, d'Orbigny, 'Pal. Franç. Terr. Crét.,' vol. iii, p. 352, pl. cccxiii, figs. 1, 2; Pictet and Campiche, 'Foss. Terr. Crét. Ste. Croix' ('Matér. Pal. Suisse,' ser. 4, 1865), p. 84, pl. cvi, figs. 4—6.

² 'Quart. Journ. Geol. Soc.,' vol. i (1845), p. 239. Morris, 'Cat. Brit. Foss.,' ed. 2 (1854), p. 176.

³ An imperfect specimen of *Goniomya* from the Tealby Limestone of Claxby is in the Sedgwick Museum, Cambridge.

Ornamentation consists of rounded ribs; those in front of the umbones are nearly straight and slope obliquely backwards and downwards; those behind the umbones are curved and more or less nearly parallel to the posterior and postero-dorsal margins; near the ventral margin the ribs become more nearly concentric and are often less distinct (especially on the median part) than on the dorsal portion of the shell.

Affinities.—This species differs from *G. designata* (Goldfuss)¹ in the smaller curvature of the ventral margin, and in the truncated form of the posterior margin. It is closely allied to *G. consignata*, Römer,² but the anterior curvature of the umbones is more marked.

Remarks.—This species has been identified by comparison with a specimen given me by M. Raoul Fortin from the same locality as the type.

Type.—From the Cenomanian of Mte. Ste. Catherine, Rouen.

Distribution.—Upper Greensand (zone of *Schlœnbachia rostrata*) of Blackdown, Devizes, and near Maiden Bradley. Base of Chalk Marl of Chard.³

Family—PLEUROMYIDÆ, Zittel.

Genus—PLEUROMYA, L. Agassiz, 1842.

(‘Études crit. Moll. Foss.’ Myes, p. 231.)

PLEUROMYA ORBIGNIANA (*Rouillier*), 1847. Plate XLIII, figs. 1, 2 *a*—*c*.

1847. PANOPÆA ORBIGNIANA, C. Rouillier. Bull. Soc. Imp. Nat. Moscou, vol. xx, p. 407; vol. xxi (1848), p. 281, pl. G, fig. 24.

Description.—Shell oval, convex, inequilateral, with a small posterior gape. Anterior and posterior margins rounded. Ventral margin considerably convex. Umbones moderately prominent, incurved. Shell depressed in front of and behind the umbones. Surface nearly smooth, but ornamented with linear, radial ribs, which are sometimes parallel, sometimes irregular; in some places the ribs are replaced by rows of minute tubercles.

Affinities.—The English specimens agree closely with examples from the Lower

¹ ‘Petref. Germ.’ vol. ii (1840), p. 264, pl. cliv, fig. 13. Holzapfel, ‘Mollusk. Aachen. Kreide’ (Palæontographica, vol. xxxv, 1889), p. 153.

² ‘Die Verstein. d. nord-deutsch. Kreidegeb.’ (1841), p. 75, pl. x, fig. 3. Müller, ‘Mollusk. Untersen. v. Braunschweig u. Ilse’ (1898), p. 71, pl. x, fig. 7.

³ A small specimen of *Goniomya* has been found in the Chalk of Trimmingham by Mr. R. M. Brydone.

Volgian of Moscow, which were identified by Prof. Pavlow, but their resemblance to Rouillier's figure is not quite so close. Some of the smaller specimens approach *P. peregrina* (d'Orbigny¹), which is said to differ from *P. Orbigniana* by smaller curvature of the ventral margin, the presence of a shallow depression extending to the ventral margin below the umbones, and by the ornamentation consisting of radial rows of minute tubercles instead of linear ribs. One specimen from Spilsby, however, shows both types of ornamentation, suggesting that the two species are not really distinct. The hinge is not seen in any of the English specimens of *P. Orbigniana*, but the figure given by Rouillier, although not quite satisfactory, is suggestive of *Panopea*; the form of the shell, however, resembles that of some Jurassic species of *Pleuromya*.

Distribution.—Spilsby Sandstone (zone of *Belemnites lateralis*) of Donnington.

Family—POROMYACIDÆ, Dall.

Genus—LIOPISTHA, F. B. Meek, 1864.

(‘Check List Invert. Foss. N. America,’ pp. 12, 32; T. A. Conrad in Kerr’s ‘Report Geol. Survey N. Carolina,’ vol. i, 1875, Appendix A, p. 28; Meek, ‘Invert. Cret. and Tert. Foss. U. Missouri,’ 1876, p. 227.)

Section—PSILOMYA, Meek, 1876.

(Ibid., p. 229.)

LIOPISTHA (PSILOMYA) GIGANTEA (*Sowerby*), 1818. Plate XLIII, figs. 3, 4; Plate XLIV, figs. 1, 2.

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| 1811. | CORBULA ? | J. Parkinson. | Organic Remains, vol. iii, p. 226. |
| 1818. | — | GIGANTEA, J. Sowerby. | Min. Conch., vol. iii, p. 13, pl. ccix, figs. 5—7. |
| 1850. | PHOLADOMYA — | A. d'Orbigny. | Prodr. de Pal., vol. ii, p. 157. |
| 1854. | THETIS — | J. Morris. | Cat. Brit. Foss., ed. 2, p. 227. |
| 1865. | — ? — | F. J. Pictet and G. Campiche. | Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), pp. 199, 210. |
| 1870. | POROMYA ? — | F. Stoliczka. | Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 42. |
| 1882. | LIOPISTHA — | P. de Loriol. | Gault de Cosne, p. 45, pl. vi, figs. 1—5. |

¹ Murchison, Verneuil, and Keyserling, ‘Géol. de la Russie de l'Europe,’ vol. ii (1845), p. 468, pl. xl, figs. 10—12. The hinge is figured by Zittel, ‘Handbuch d. Paläont.,’ vol. ii, p. 125, fig. 179, and ‘Grundzüge d. Paläont.,’ ed. 2 (1903), p. 330, fig. 732.

Description.—Shell large, rather thick, oval, elongate, inflated, the posterior part compressed, very inequilateral. Anterior part very short, with rounded margin, but its dorsal part only slightly curved. Ventral margin forming a considerable curve. Posterior margin obliquely truncated, more or less rounded. Postero-dorsal margin nearly straight. Umbones large, prominent, pointed, inrolled, and with a more or less considerable forward curvature. A rounded carina extends from the front of the umbones to the middle of the anterior margin and forms the boundary of a deeply excavated area in front of the umbones.

Ornamentation consists of broad, rounded, concentric ribs on the dorsal part of the valves except on the anterior excavated area. In passing ventrally these ribs become less prominent and are soon represented by concentric lines. Rather widely separated radial rows of minute tubercles are present and leave small pits when broken off. Near the umbo small radial ribs are present.

Measurements :

	(1)	(2)	(3)
Length . . .	128	110	90 mm.
Height . . .	89	82	68 „

(1—3) Blackdown.

Affinities.—This species resembles *L. (Psilomya) superba* (Stoliczka¹), but differs in outline, in the concentric ribs being confined to the dorsal part of the shell, and in the less inflated form of the valves.

Remarks.—In the small examples of this species the shell is relatively shorter and more nearly orbicular in outline and the concentric ribs cover the whole or nearly the whole of the valves. The radial ribs near the umbo are seen in only a few specimens.

Type.—From Blackdown, in the British Museum.

Distribution.—Upper Greensand (zone of *Schlenbachia rostrata*) of Blackdown.

LIPISTHA, sp. Plate XLIII, fig. 5a—c.

Description.—Shell oval, slightly inequilateral, inflated, posterior part compressed, with a shallow furrow near the postero-dorsal margin, concave in front of the umbones. Anterior and posterior margins rounded; ventral margin considerably convex. Umbones prominent, curved inwards and forwards.

Ornamentation consists of numerous (about twenty-nine), narrow radial ribs bearing small tubercles, and separated by concave interspaces of greater breadth than the ribs. On the postero-dorsal part of the shell ribs are absent. The ribs are crossed by faintly marked concentric rings.

Remarks.—The only example of this species which has been seen does not

¹ 'Palæont. Indica, Cret. Fauna S. India' (1870), p. 48, pl. iii, figs. 2—4.

show the hinge, but it is provisionally referred to *Liopistha* on account of its external resemblance to some species of that genus.¹ It should be noted, however, that it is also similar to some species which are believed to belong to the genus *Pholadomya*.²

Distribution.—Red Limestone of Hunstanton.

Family—CUSPIDARIIDÆ, *Dall*.

Genus—CUSPIDARIA, *G. D. Nardo*, 1840.

(‘Ann. Sci. Lombardo-Veneto,’ vol. x, p. 49.)

CUSPIDARIA SABAUDIANA (*Pictet and Campiche*), 1864. Plate XLIII, fig. 6*a, b*;
Plate XLIV, fig. 3*a, b*.

1864. NEERA SABAUDIANA, *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 40, pl. c, figs. 5—7.

Description.—Shell inflated, oval, oblique, slightly inequivalve, anterior part sloping rapidly to the margin, posterior part compressed and produced into a pointed beak. Anterior margin rounded; ventral margin convex, curving upwards and passing gradually into the posterior margin. Umbones curved inwards and slightly backwards. A narrow postero-dorsal area is bent at an angle with the sides of the shell, and is limited by a carina.

Ornamentation consists of strong, [concentric ribs, most of which are continued on to the posterior beak, where they become rather smaller and closer together; on the sides of the ribs and in the furrows are a few faint concentric lines. Length 14 mm.; height 11 mm.

Affinities.—This species is more inflated, the anterior part is more rounded, and the concentric ribs are stronger than in *C. pulchra* (Sowerby).

Type.—From the Gault of the Perte-du-Rhône.

Distribution.—Lower Gault of Folkestone.

¹ See, for example, Stoliczka, ‘Cret. Fauna S. India,’ vol. iii (1870), pl. ii, figs. 10, 11; Moesch, ‘Mon. Pholadomyen’ (1874), pl. xxxv, fig. 5; Geinitz, ‘Das Elbthalgeb. in Sachsen’ (‘Palæontographica,’ vol. xx, pt. 2, 1873), pl. xix, figs. 6, 7; Weller, ‘Cret. Pal. New Jersey,’ vol. iv (1907), pl. lviii, figs. 3—9.

² E. g. *P. subdinensis* (d’Orbigny), ‘Pal. Franç. Terr. Crét.,’ vol. iii (1844), p. 38, pl. ccl, figs. 1—3, and ‘Prodr. de Pal.,’ vol. ii (1850), p. 157.

CUSPIDARIA UNDULATA (*Sowerby*), 1827. Plate XLIV, fig. 4.

1827. *NUCULA UNDULATA*, *J. de C. Sowerby*. Min. Conch., vol. vi, p. 104, pl. dliv, fig. 3.
 1854. *NEÆRA*? — *J. Morris*. Cat. Brit. Foss., ed. 2, p. 216.
 1866. — — *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 421.
 1871. — — *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 322.

Remarks.—A few specimens resembling *Sowerby*'s figure of *C. undulata* have been found. They appear to differ from *C. Sabaudiana* only in the less oblique form of the shell and the more convex postero-ventral margin. More specimens are needed in order to determine whether *C. Sabaudiana* and *C. undulata* are really distinct or only varieties of one species.

Type.—The type was preserved in pyrites, and came from Folkestone; it was formerly in the British Museum, but has now perished.

Distribution.—Gault of Folkestone.

CUSPIDARIA PULCHRA (*Sowerby*), 1850. Plate XLIV, figs. 5, 6.

1850. *LEDA PULCHRA*, *J. de C. Sowerby* in *F. Dixon*. Geol. Sussex, p. 346 (p. 382, ed. 2), pl. xxviii, fig. 10.
 1854. — ? — *J. Morris*. Cat. Brit. Foss., ed. 2, p. 205.
 1897. *CUSPIDARIA CAUDATA*, *H. Woods*. Quart. Journ. Geol. Soc., vol. liii, p. 393, pl. xxviii, figs. 19, 20.

Description.—Shell convex, with the posterior and antero-dorsal parts compressed; sub-triangular, oblique, somewhat inequilateral, highest in front of the umbones. Dorsal margin nearly straight. Anterior margin slightly convex. Antero-ventral margin rounded. Ventral margin curving upwards and passing gradually into the posterior margin, which forms an acute angle with the postero-dorsal margin. Umbones pointed, curved inwards and slightly backwards. Ornamentation consists of regular, concentric ribs which become indistinct on the antero-dorsal and postero-dorsal parts.

Measurements :

	(1)	(2)
Length	27	22 mm.
Height	19	15 „
Thickness	14	11 „

(1, 2) Upper Chalk, Norwich.

PLATE XXXV.

Genus—PHARUS, *Leach*.

FIGS.

- 1—3. *P. Warburtoni* (Forbes). Lower Greensand (Crackers), Atherfield. Sedgwick Museum, Cambridge. 1, 3, right valves; 2 *a*, left valve; 2 *b*, dorsal view of 2 *a*; 2 *c*, portion of anterior part $\times 8$. (P. 217.)

Genus—SOLECURTUS, *de Blainville*.

4. *S. (Azor?) Pelagi*, d'Orb. Upper Greensand, Blackdown. Sedgwick Museum. Right valve. (P. 218.)
- 5, 6. *S.?* (*Azor?*) *Acteon*, d'Orb. Left valves. 5, Upper Greensand, Haldon; British Museum, No. 34801. 6, Cenomanian, Dunscombe; Sedgwick Museum. (P. 219.)

Genus—LEPTOSOLEN, *Conrad*.

- 7, 8. *L. Dupinianus* (d'Orb.). Gault, Black Ven. Sedgwick Museum. 7, right valve; 8, left valve. (P. 219.)

Genus—PANOPEA, *Ménard de la Groye*.

- 9—14. *P. gurgitis* (Brongn.). Lower Greensand (Crackers), Atherfield. Sedgwick Museum, Cambridge. (P. 222.)

9. var. *neocomiensis*, Leym. *a*, left valve; *b*, dorsal view; *c*, ornamentation $\times 8$.

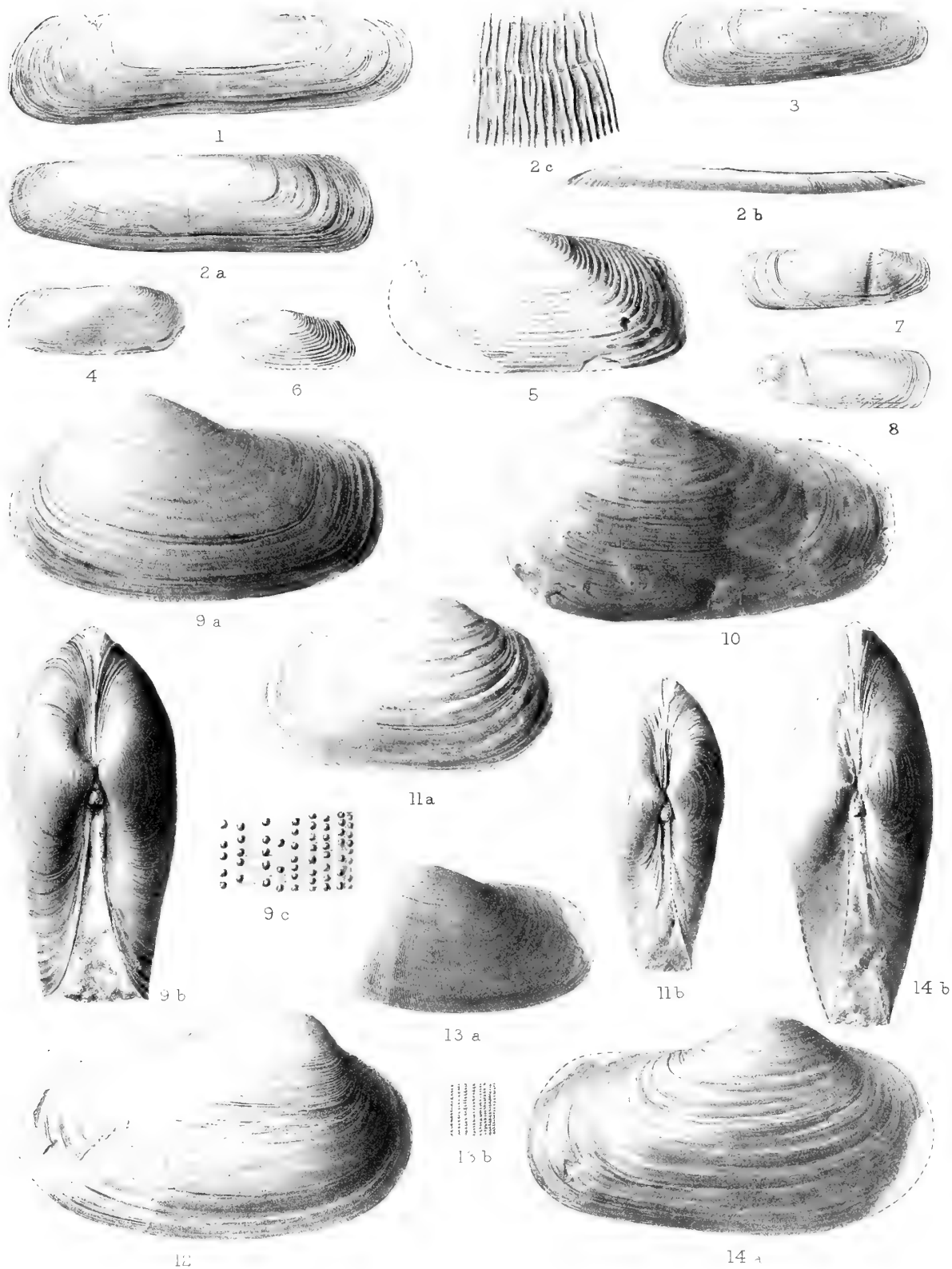
10. var. *a*. Left valve.

11. var. *a*. *a*, right valve; *b*, dorsal view.

12. Right valve.

13. var. *neocomiensis*, Leym. *a*, left valve; *b*, ornamentation $\times 4$.

14. *a*, right valve; *b*, dorsal view.



CRETACEOUS LAMELLIBRANCHIA.

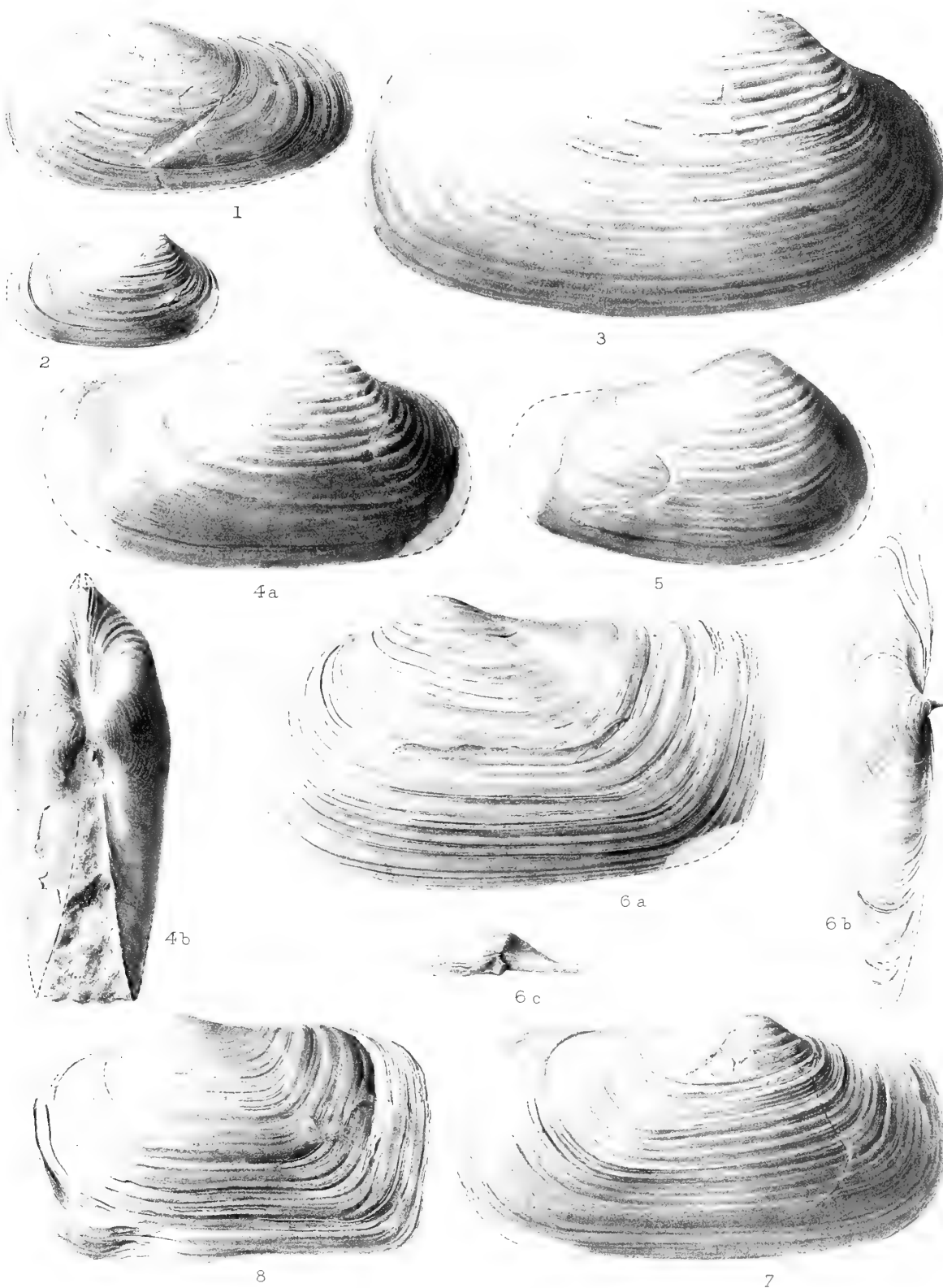
PLATE XXXVI.

PANOPEA (*continued*).

FIGS.

1—8. *P. gurgitis* (Brongn.). 1—5, Lower Greensand, Atherfield. 6—8, Upper Greensand, Blackdown. (P. 222.)

1. Crackers. Sedgwick Museum. Left valve.
2. Crackers. Sedgwick Museum. Right valve.
3. var. *plicata*, Sow. *Perna*-bed. Sedgwick Museum. Internal cast. Right valve.
4. var. *plicata*, Sow. Probably *Perna*-bed. York Museum. *a*, right valve; *b*, dorsal view.
5. Lobster clay. Sedgwick Museum. Internal cast. Right valve.
6. var. *plicata*, Sow. British Museum, No. L577. *a*, left valve; *b*, dorsal view; *c*, hinge of same.
7. var. *plicata*, Sow. British Museum, No. L17122. Right valve.
8. Short form of var. *plicata*, Sow. British Museum, No. L17120. Left valve.



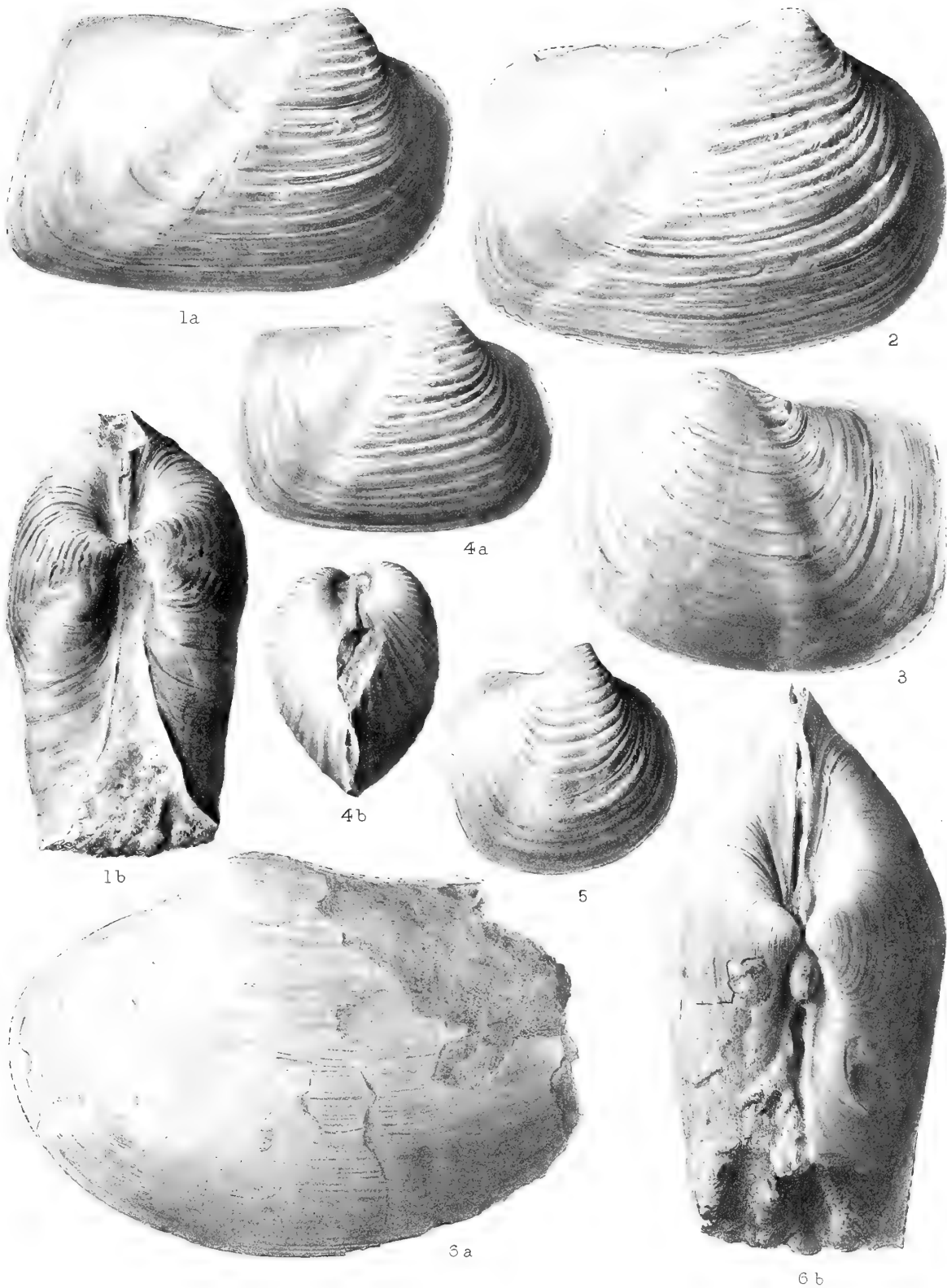
CRETACEOUS LAMELLIBRANCHIA.

PLATE XXXVII.

PANOPEA (*continued*).

FIGS.

- 1—5. *P. mandibula* (Sow.). Upper Greensand. Sedgwick Museum, Cambridge.
Internal casts. (P. 228.)
1. Ventnor. *a*, right valve; *b*, dorsal view.
 2. Devizes. Right valve.
 3. Ventnor. Left valve.
 4. Devizes. *a*, right valve; *b*, anterior view.
 5. Ventnor. Right valve.
6. *P. ovalis*, Sow. Upper Greensand, Blackdown. The Type. Bristol Museum. *a*, portion of left valve; *b*, dorsal view. (P. 229.)



CRETACEOUS LAMELLIBRANCHIA.

PLATE XXXVIII.

PANOPEA (*continued*).

FIGS.

1. *P. Meyeri*, Woods. Upper Greensand, Blackdown. Sedgwick Museum, Cambridge. *a*, right valve; *b*, dorsal view. (P. 229.)
2. *P. spilsbiensis*, Woods. Spilsby Sandstone, Donnington. Sedgwick Museum. Internal cast. *a*, right valve; *b*, dorsal view. (P. 222.)

Genus—MARTESIA, Leach.

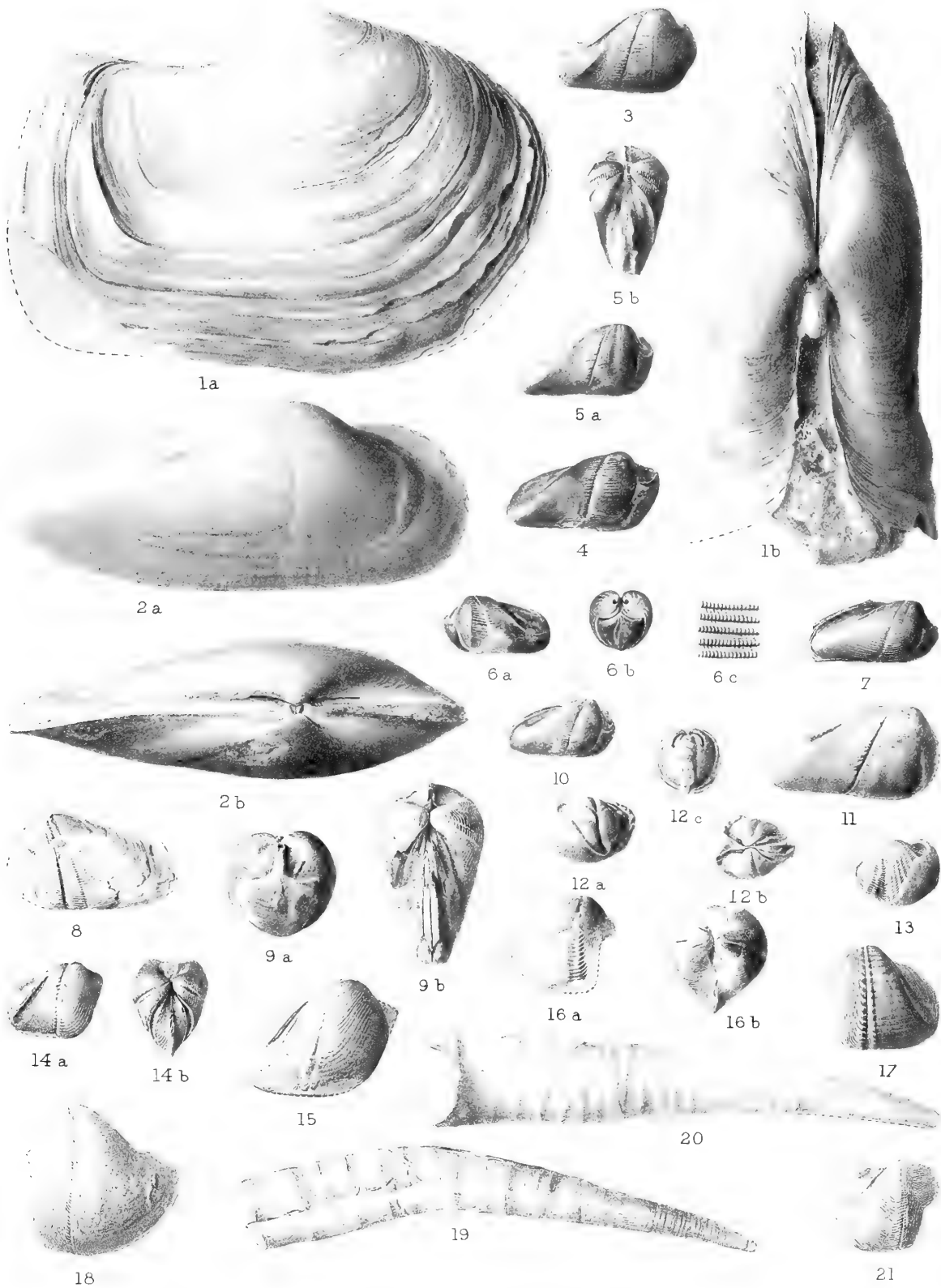
- 3—10. *M. constricta* (Phill.). 3—6, Speeton Clay, Speeton. 7—10, Gault, Folkestone. Mainly internal casts. (P. 231.)
 3. York Museum. Right valve.
 4. British Museum, No. L21607. Right valve. $\times 1\frac{1}{2}$.
 5. Sedgwick Museum. *a*, right valve; *b*, dorsal view of both valves. $\times 1\frac{1}{2}$.
 6. Sedgwick Museum. *a*, left valve, $\times 1\frac{1}{2}$; *b*, anterior view, $\times 1\frac{1}{2}$; *c*, portion of shell near the ventral margin $\times 10$.
 7. Museum of Practical Geology, No. 23487. Right valve. $\times 1\frac{1}{2}$.
 8. British Museum, No. L4997. Left valve with shell preserved. $\times 2$.
 9. British Museum, No. L4997. *a*, anterior view; *b*, dorsal view. Part of the shell is preserved. $\times 2$.
 10. Museum of Practical Geology, No. 23486. Right valve.
11. *M. prisca* (Sow.). Hythe Beds of Maidstone. Museum of Practical Geology, No. 23474. Internal cast of right valve. (P. 232.)
- 12, 13. *M. ? rotunda* (Sow.). Chalk Rock, Cuckhamsley. Sedgwick Museum. 12, internal cast; *a*, left valve; *b*, dorsal view; *c*, anterior view. 13, right valve—drawn from a wax mould of the exterior, partly restored. $\times 2$. (P. 233.)

Genus—TURNUS, Gabb.

- 14, 15. *T. Dallasi* (Walker). Lower Greensand, Potton. Sedgwick Museum. Internal casts. 14, the Type; *a*, right valve; *b*, dorsal view. 15, right valve. $\times 2$. (P. 233.)
- 16, 17. *T. sp.* Gault, Folkestone. $\times 1\frac{1}{2}$. (P. 234.)
 16. British Museum, No. L4996. *a*, right valve, with part of shell preserved; *b*, dorsal view.
 17. Sedgwick Museum. Internal cast of left valve.
18. *T. sp.* Upper Greensand, Blackdown. British Museum, No. 24335. Left valve. $\times 1\frac{1}{2}$. (P. 235.)
- 19, 20. *T. ? amphisbæna* (Goldf.). Upper or Middle Chalk, Sussex. Sedgwick Museum. (P. 235.)

Genus—TEREDO, Linnæus.

21. *T. gaultina*, Woods. Gault, Folkestone. Museum of Practical Geology, No. 23485. Right valve. $\times 2$. (P. 237.)



CRETACEOUS LAMELLIBRANCHIA.

PLATE XXXIX.

Genus—PLECTOMYA, *de Loriol*.

FIGS.

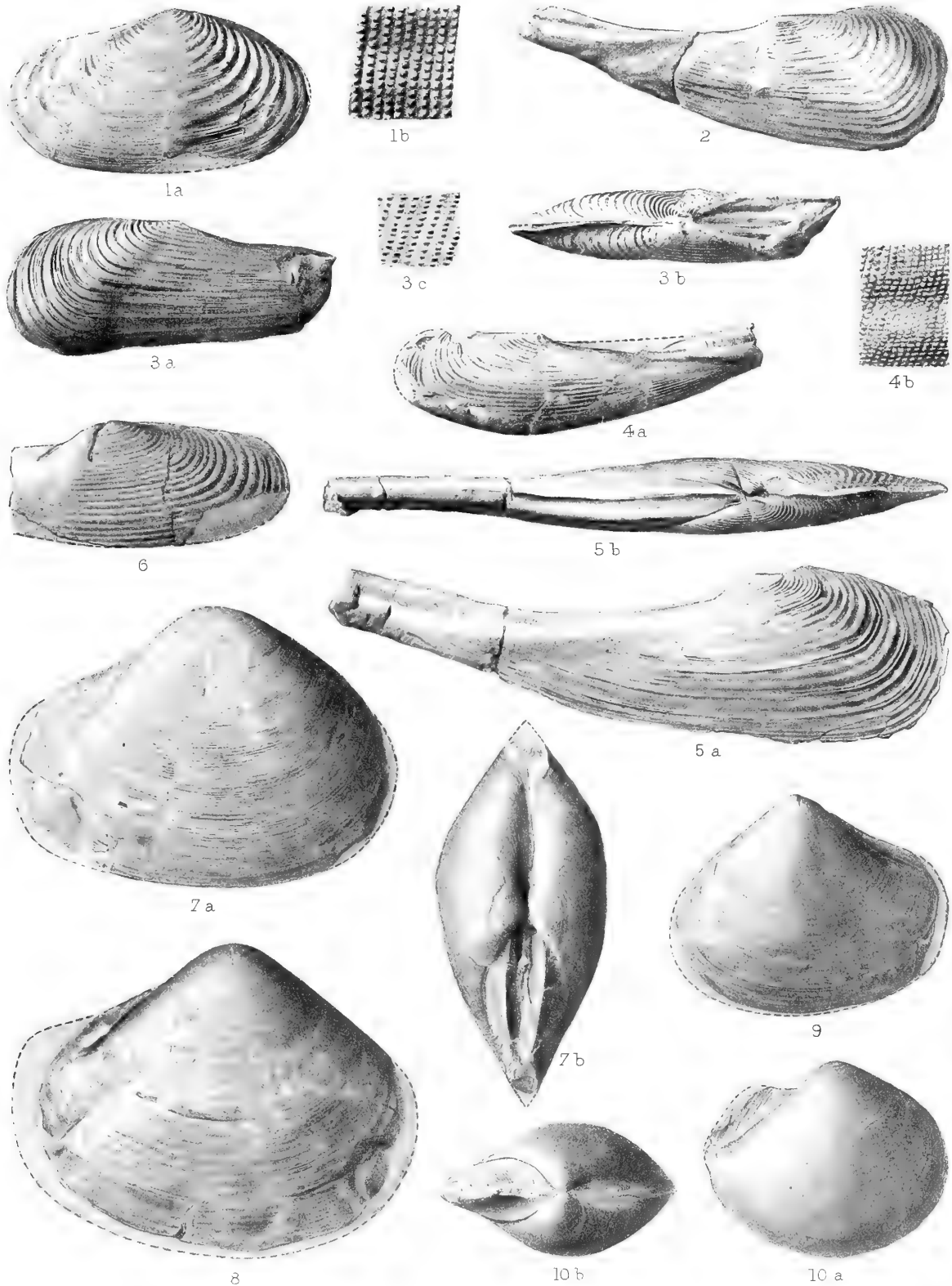
1. *P. anglica*, Woods. Lower Greensand (Crackers), Atherfield. Sedgwick Museum, Cambridge. *a*, right valve; *b*, ornamentation $\times 16$. (P. 238.)

Genus—ANATINA, *Lamarck*.

- 2—4. *A. (Cercomya) gurgitis*, Pict. and Camp. Lower Greensand. (P. 239.)
 2. *Perna*-bed, Isle of Wight. British Museum, No. L436. Right valve.
 3. Crackers, Atherfield. Sedgwick Museum. *a*, part of left valve; *b*, dorsal view; *c*, ornamentation near the antero-ventral margin $\times 12$.
 4. Crackers, Atherfield. Sedgwick Museum. *a*, left valve; *b*, ornamentation near the antero-ventral margin $\times 10$.
5. *A. (Cercomya)* sp. Upper Greensand, Isle of Wight. British Museum, No. 48626. Internal cast. *a*, right valve; *b*, dorsal view. (P. 239.)
6. *A. (Cercomya)* sp. Upper Greensand, Warminster. British Museum, No. 88926. Internal cast of part of right valve. (P. 240.)

Genus—THRACIA, *Leach*.

- 7—9. *T. Phillipsi*, Röm. Speeton Clay, Speeton. (P. 240.)
 7. Mr. Stather's Collection. *a*, right valve; *b*, dorsal view.
 8. Sedgwick Museum. Right valve.
 9. Sedgwick Museum. Left valve.
10. *T. rotundata* (Sow.). Hythe Beds, Lympne. Museum of Practical Geology, No. 23470. *a*, right valve; *b*, dorsal view. (P. 241.)



CRETACEOUS LAMELLIBRANCHIA.

PLATE XL.

THRACIA (*continued*).

FIGS.

- 1—3. *T. Robinaldina* ? (d'Orb.). Lower Greensand, Atherfield. Sedgwick Museum. (P. 242.)
1. *Perna*-bed. *a*, left valve; *b*, dorsal view.
 2. Crackers. Left valve.
 3. Crackers. Right valve.
- 4—6. *T. Sanctæ-Crucis*, Pict. and Camp. Gault. Left valves. 4, Folkestone; Sedgwick Museum. 5, Black Ven; Museum of Practical Geology, No. 23484. 6, Folkestone; Museum of Practical Geology, No. 1662. (P. 243.)
- 7—9. *T. sp.* 7, 8, Gault, Black Ven; Museum of Practical Geology, Nos. 23482, 23483, left valves. 9, Upper Greensand, Blackdown; Museum of Practical Geology, No. 19813; *a*, left valve; *b*, dorsal view. (P. 243.)
- 10—13. *T. carinifera* (Sow.). Chalk Marl. (P. 244.)
- 10, 11. Ventnor. Sedgwick Museum. Right valves.
 12. Chard. Museum of Practical Geology, No. 23500, *a*, right valve; *b*, dorsal view.
 13. Near Beaminster. Museum of Practical Geology, No. 23499. Ornamentation $\times 12$.

Genus—PHOLADOMYA, *Sowerby*.

14. *P. gigantea* (Sow.). Lower Greensand (Crackers), Atherfield. Sedgwick Museum. Right valve. (P. 246.)

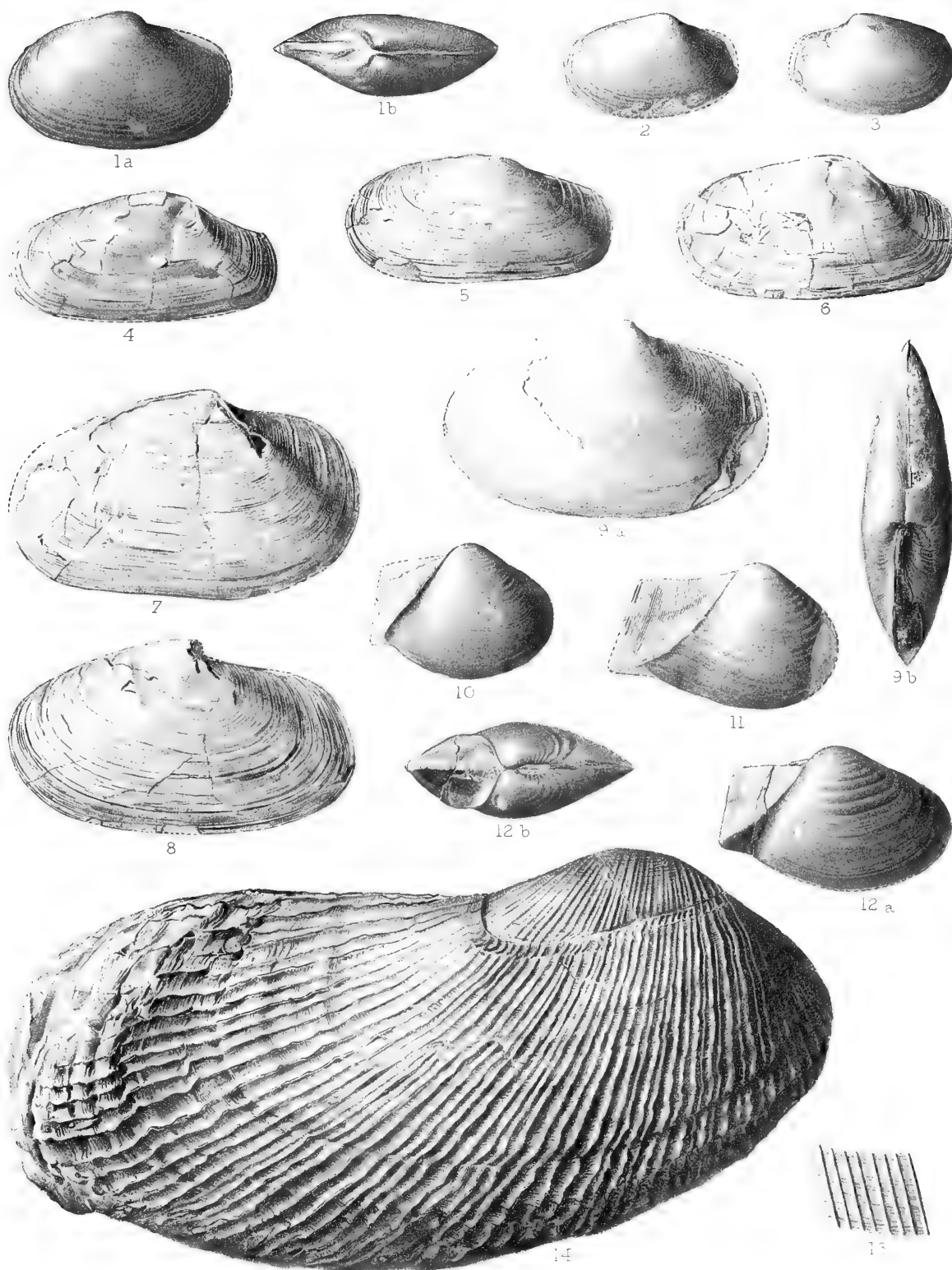
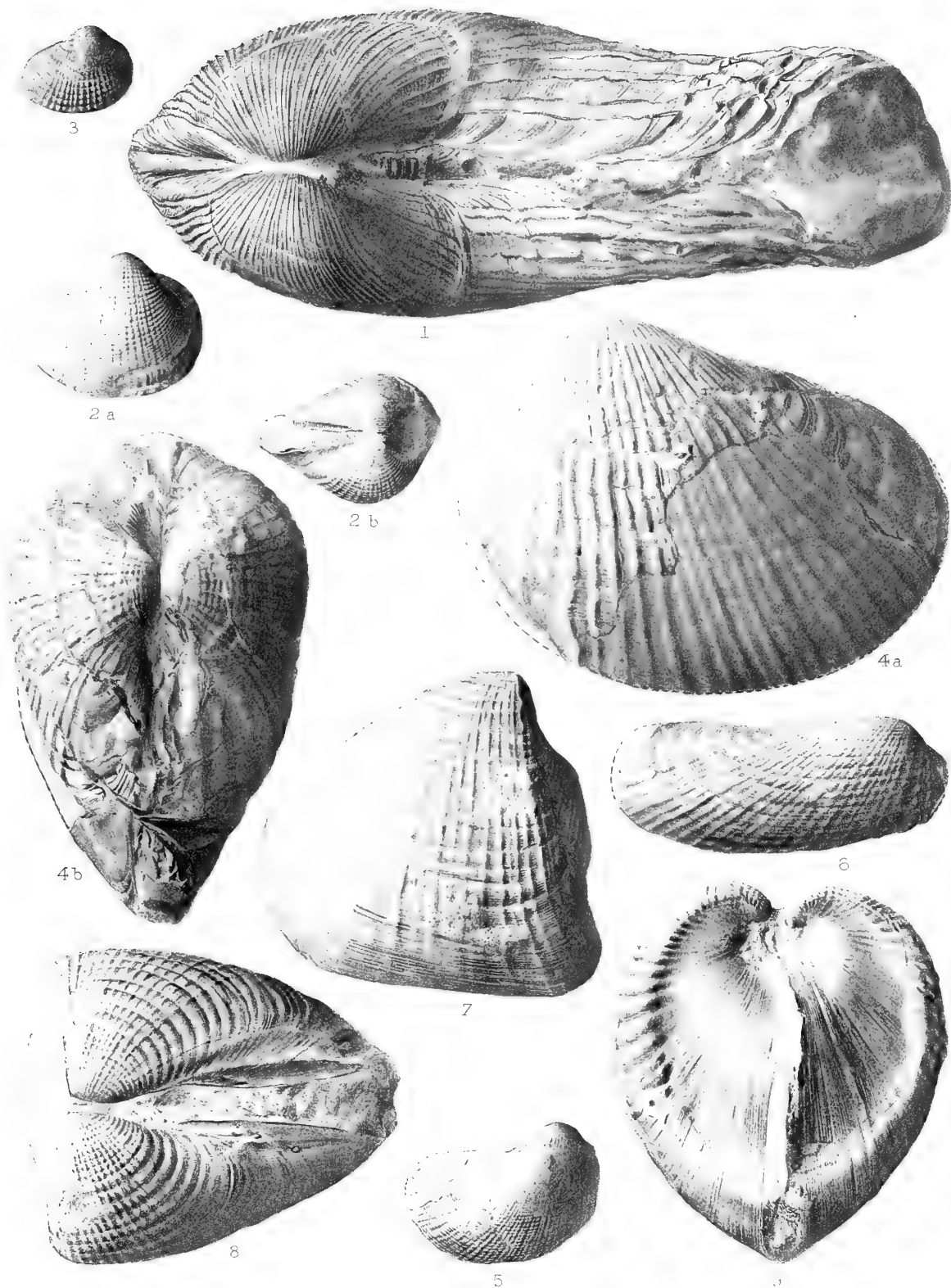


PLATE XLI.

PHOLADOMYA (*continued*).

FIGS.

1. *P. gigantea* (Sow.). Lower Greensand (Crackers), Atherfield. Sedgwick Museum. Dorsal view of specimen figured on Plate XL. (P. 246.)
- 2, 3. *P. Cornueliana* (d'Orb.). Lower Greensand (Crackers), Atherfield. Sedgwick Museum, Cambridge. 2 *a*, right valve; *b*, dorsal view; 3, right valve. (P. 245.)
4. *P. speetonensis*, Woods. Speeton Clay, Speeton. Museum of Practical Geology, No. 23620. *a*, left valve; *b*, dorsal view. (P. 248.)
5. *P. Martini*, Forbes. Lower Greensand (Crackers), Atherfield. Sedgwick Museum. Right valve. (P. 249.)
6. *P. Fabrina*, d'Orb. Gault, Black Ven. Sedgwick Museum. Right valve, compressed dorso-ventrally. (P. 250.)
- 7—9. *P. decussata* (Mant.). Chalk Marl. (P. 250.)
 7. Eastbourne. Sedgwick Museum. Right valve.
 8. Ventnor. Sedgwick Museum. Dorsal view.
 9. Ventnor. Sedgwick Museum. Anterior view.



CRETACEOUS LAMELLIBRANCHIA.

PLATE XLII.

PHOLADOMYA (*continued*).

 FIGS.

1. *P. decussata* (Mant.). Chalk Marl, Chertsey. York Museum. Left valve. (P. 250.)
2. *P. cordata*, Tate. Upper Chalk (White Limestone, zone of *Belemnitella mucronata*), Tamblacht, co. Derry. Museum of Practical Geology, No. 23628. *a*, left valve; *b*, dorsal view; *c*, anterior view. (P. 253.)

Genus—MYOPHOLAS, *Douvillé*.

3. *M. sp. cf. semicostata* (Agassiz). Lower Greensand, Furze Hill, Faringdon. Sedgwick Museum. Internal cast. *a*, right valve; *b*, dorsal view. (P. 253.)

Genus—GONIOMYA, *Agassiz*.

- 4, 5. *G. Archiaci* (Pict. and Ren.) Lower Greensand (Crackers), Atherfield. Sedgwick Museum. Right valves. 4 *b*, dorsal view of 4 *a*. (P. 254.)
- 6, 7. *G. Mailleana* (d'Orb.). Sedgwick Museum. 6, Base of Chalk Marl, Chard; *a*, part of left valve; *b*, dorsal view. 7, Upper Greensand, near Maiden Bradley; right valve. (P. 255.)

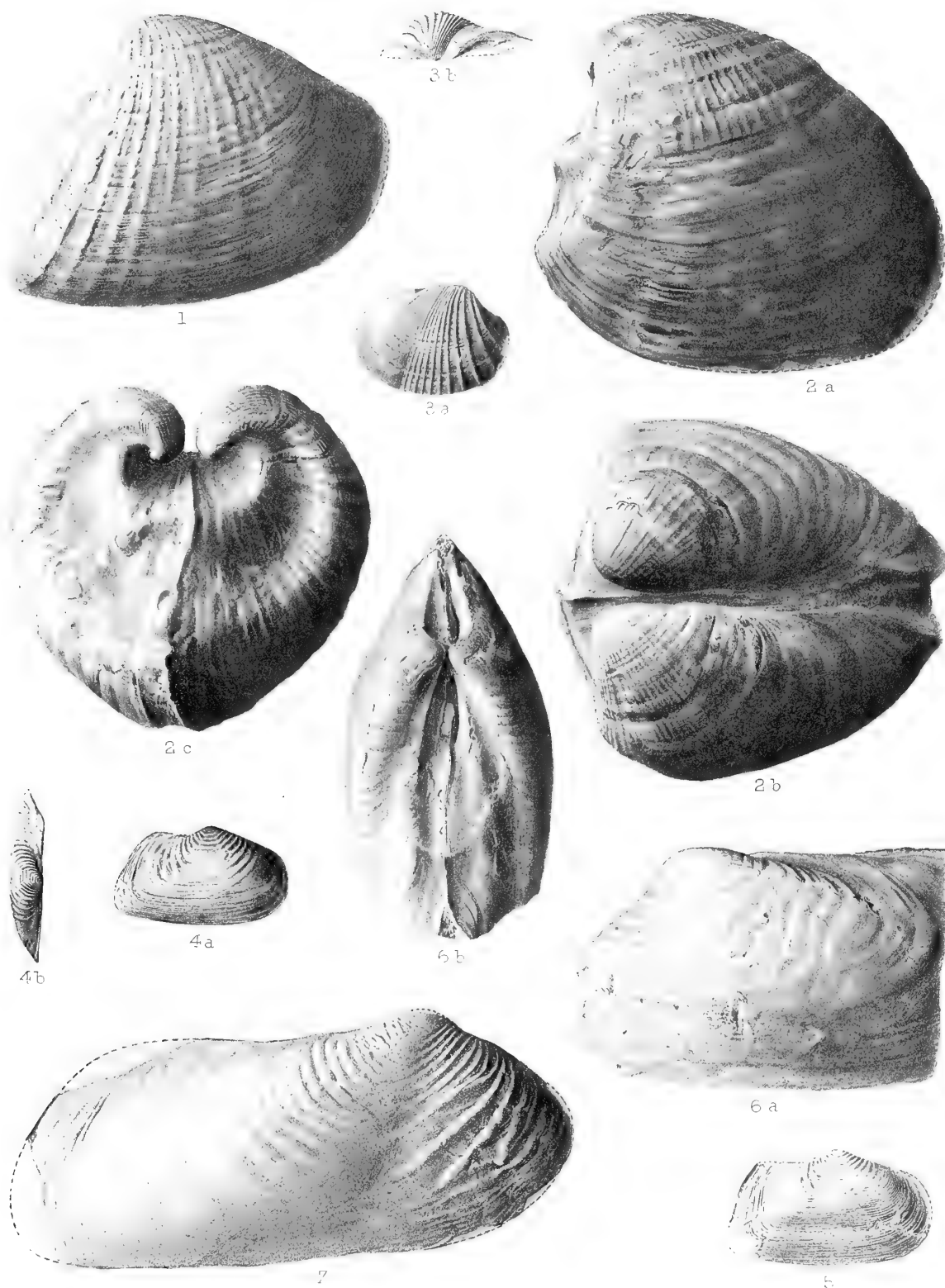


PLATE XLIII.

Genus—PLEUROMYA, *Agassiz*.

FIGS.

- 1, 2. *P. Orbigniana* (Rouillier). Spilsby Sandstone, Donnington. Sedgwick Museum, Cambridge. 1 *a*, right valve; 1 *b*, dorsal view. 2, ornamentation $\times 12$; *a*, near middle of valve; *b*, near the ventral margin; *c*, between *a* and *b*. (P. 256.)

Genus—LIOPISTHA, *Meek*.

- 3, 4. *L. (Psilomya) gigantea* (Sow.). Upper Greensand, Blackdown. Sedgwick Museum. 3 *a*, left valve; *b*, hinge of the same. 4, umbo of right valve $\times 6$. (P. 257.)

5. *L.*, sp. Red Limestone, Hunstanton. British Museum, No. 83628. *a*, right valve; *b*, dorsal view; *c*, ornamentation $\times 6$. (P. 258.)

Genus—CUSPIDARIA, *Nardo*.

6. *C. Sabaudiana* (Pict. and Camp.). Gault, Folkestone. Museum of Practical Geology, No. 23821. *a*, left valve $\times 1\frac{1}{2}$; *b*, dorsal view $\times 1\frac{1}{2}$. (P. 259.)

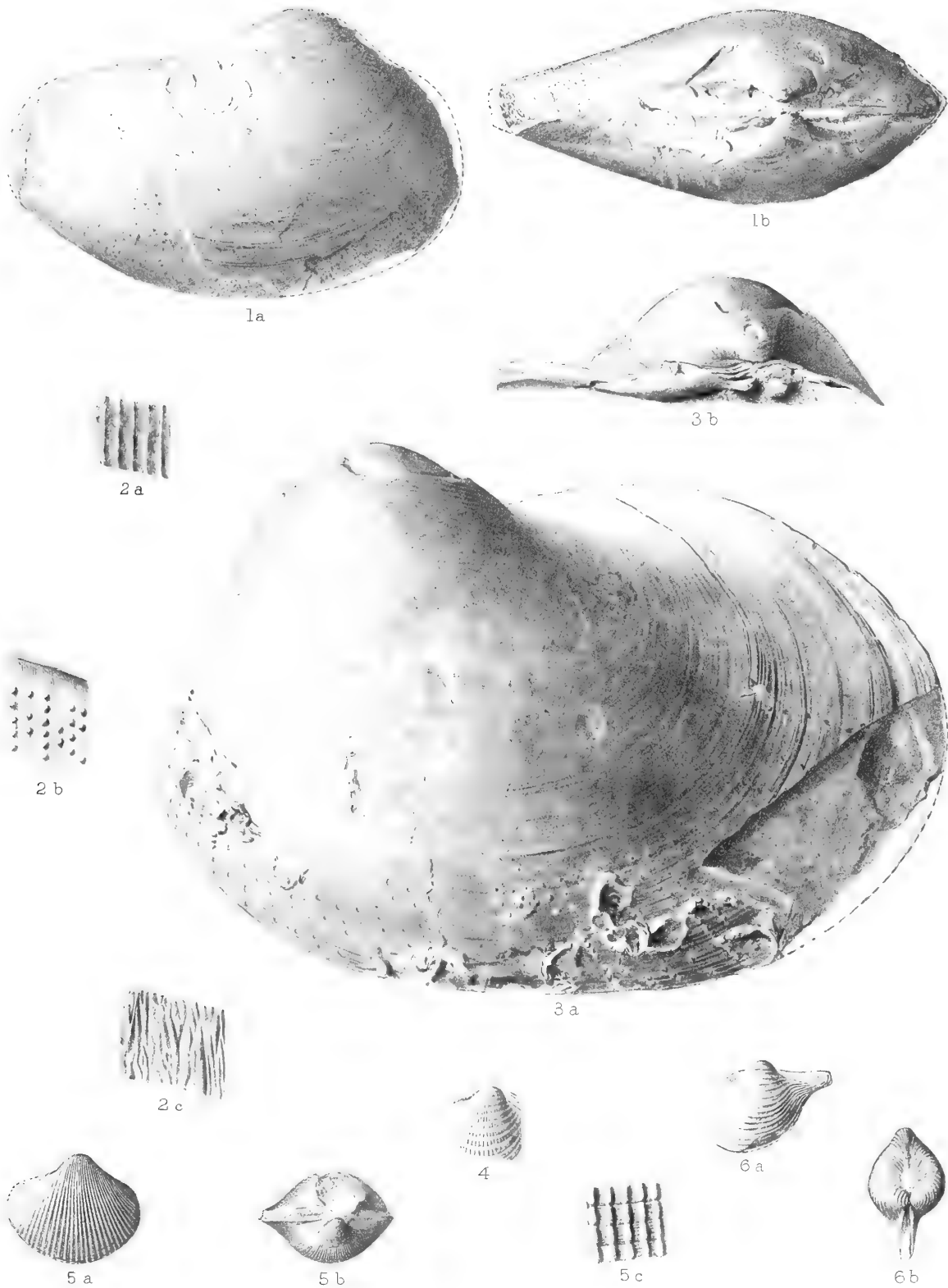


PLATE XLIV.

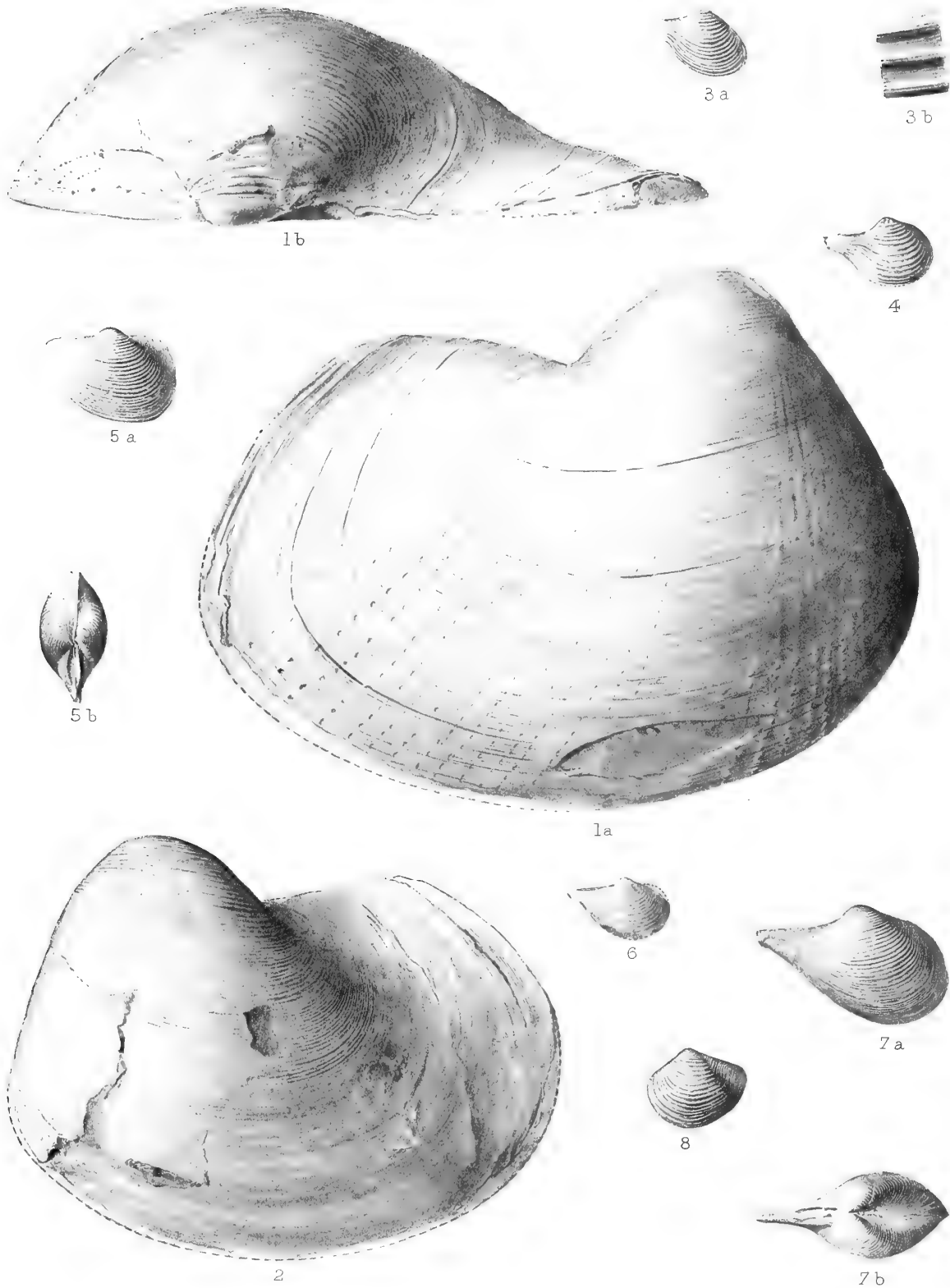
LIOPISTHA (*continued*).

FIGS.

- 1, 2. *L. (Psilomya) gigantea* (Sow.). Upper Greensand, Blackdown. Sedgwick Museum, Cambridge. 1 *a*, right valve; 1 *b*, dorsal view of the same. 2, left valve. (P. 257.)

CUSPIDARIA (*continued*).

3. *C. Sabaudiana* (Pict. and Camp.). Gault, Folkestone. Sedgwick Museum. *a*, right valve; *b*, ornamentation $\times 5$. (P. 259.)
4. *C. undulata* (Sow.). Gault, Folkestone. Sedgwick Museum. Right valve. (P. 260.)
- 5, 6. *C. pulchra* (Sow.). 5, Upper Chalk, Norwich. Norwich Museum. *a*, internal cast of right valve; *b*, dorsal view. 6, Chalk Rock, Henley Park; Sedgwick Museum, from Mr. L. Treacher's Collection; right valve. (P. 260.)
7. *C. pulchra?* (Sow.). Upper Greensand, Devizes. British Museum, No. L21785. Internal cast, somewhat crushed. *a*, right valve; *b*, dorsal view. (P. 261.)
8. *C. ?* sp. Chalk Marl, Ventnor. British Museum, No. 38266. (P. 261.)



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DESCRIPTION OF THE FOSSIL REMAINS OF MOLLUSCA FOUND IN
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DESCRIPTION
OF THE
FOSSIL REMAINS OF MOLLUSCA
FOUND IN THE
CHALK OF ENGLAND.
CEPHALOPODA.

BY
DANIEL SHARPE, PRES. GEOL. SOC., F.R. & G.S.

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A MONOGRAPH
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JURASSIC.

BY
JOHN PHILLIPS,
M.A.OXON., LL.D.DUBLIN, LL.D.CAMBRIDGE, D.C.L.OXON., F.R.S., F.G.S., ETC.; PROFESSOR OF GEOLOGY
IN THE UNIVERSITY OF OXFORD.

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